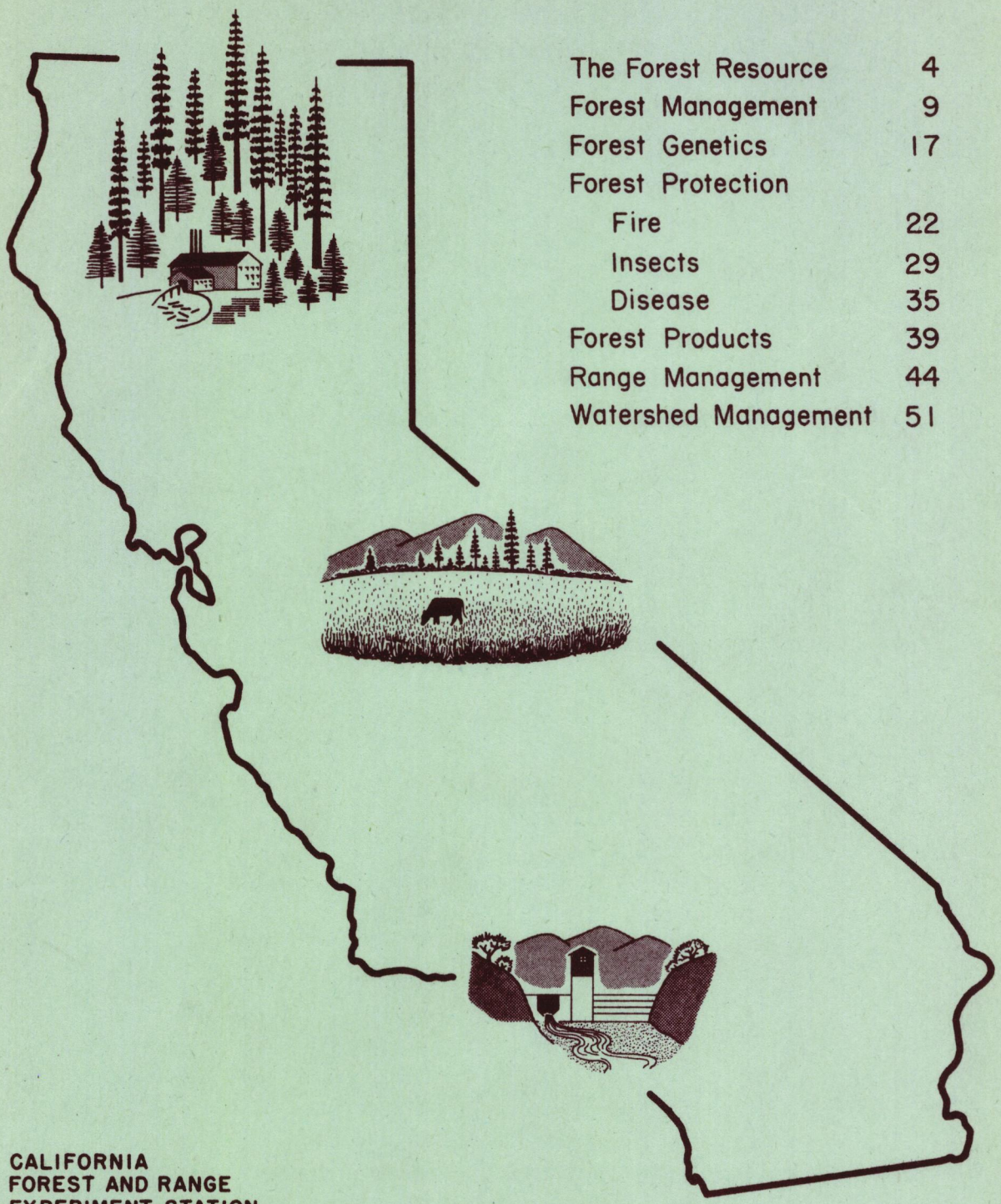
ANNUAL REPORT - 1954

FOREST RESEARCH IN CALIFORNIA



CALIFORNIA
FOREST AND RANGE
EXPERIMENT STATION
GEORGE M. JEMISON, DIRECTOR

FOREST SERVICE — U. S. DEPARTMENT OF AGRICULTURE

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INTRODUCTION

Up and down California in 1954, anyone could see evidence of increasing interest in management of forest and range land. Humboldt County, for instance, completed an analysis of forest conditions there and started planning ways to assure future timber crops for its booming forest industries. Consulting firms reported that more land owners in forest areas are placing their timberland under management by technically trained foresters. Representatives of a dozen public and private agencies, including the Station's fire research staff, joined in cooperative fire-control studies to see what new methods can be devised to combat the large conflagrations that cause 90 percent of fire losses. The State Board of Forestry and Water Resources Board held their first joint meeting to discuss management of watersheds for improved water yield and better control of floods.

During the year the Station brought together some new facts on the extent and condition of these natural resources. We completed the first inventory of the State's 42.5 million acres of commercial and non-commercial forest land. This survey showed that California forests contain 360 billion board feet of sawtimber, enough to support the present high level of cutting for many years if growth rates are maintained. The survey also showed we are cutting fir sawtimber at a rate well below its annual growth, but the more valuable pines two or three times as fast as they are growing.

Several segments of the Station's program showed ways to correct this imbalance and maintain high productivity of timber stands. Studies at Blacks Mountain Experimental Forest, for example, showed that unit area control offers a way to increase growth on cutover pine forests and improve the efficiency of forest administration. Development work was started on use of paper overlays to increase the merchantability of common grades of lumber. Surveys in cooperation with State and Federal agencies classified and mapped soils and vegetation to provide basic information needed in choosing the best use of wild land.

At the beginning of the year the Department of Agriculture's research in control of forest insects and disease was placed in the Forest Service. Research in California is now a part of the Station's activities, and is progressing along lines established before Departmental reorganization.

Surveys showed that timber losses caused by insects rose slightly in 1954. On the average insect enemies of California forests destroy nearly one-half of 1 percent of the timber stand

each year. This seems like a small loss, at first glance, but it amounts to more than 1.5 billion board feet a year. In effect, insects kill nearly one-fifth as much timber as is harvested by the entire logging industry of the State. Forest insect research during the year was directed at three problems: Improvement of residual-type sprays to control bark beetles, resistance of certain pines to bark beetles, and biology of the lodgepole needle miner, an insect which together with the mountain pine beetle threatens to create a new ghost forest in parts of Yosemite National Park.

We compiled the first comprehensive estimate of timber losses caused by wood-decaying fungi. The figures show that decay is a major source of loss--altogether nearly 80 billion board feet are decayed, enough timber if sound to support the State's sawmill industry for 16 years. To help foresters plan harvesting and salvage operations, forest disease specialists gathered information on the amount of cull in various commercial timber trees, and on the rate at which fire-killed timber is destroyed by decay and insects. Other studies were aimed at better understanding and control of some common forest diseases--root rot, needle blight, and blister rust.

A need for larger forage crops was brought home to livestock ranchers and game managers during the year. Ranchers increased production of cattle and sheep a few percent in the face of generally lower prices for livestock. At the same time land used to grow forage crops was taken out of production to provide space for new homes and industries. Deer continued to increase in number, damaging farm crops and depleting already damaged winter ranges that are grazed by both livestock and deer. One herd along the Oregon-California border, for example, now numbers 18,000 deer, but the herd's winter range in California has a grazing capacity of only 12,000 head.

Research recently started in northeastern California began to show some ways to meet the demand for forage. Grazing management alone has started recovery of native bunchgrass on an experimental range allotment, and reseeding and weed control promise to add to the grazing capacity of this range. A cooperative study on restoration of game ranges has gathered convincing evidence that browse forage can be reseeded on deer ranges. In several parts of the State, brush burning studies have turned up new information on use of fire to help improve forage production on brushlands. Soil-vegetation surveys and a new brushland map helped sharpen the sights of land managers looking for likely brushlands to improve.

Study of streamflow records showed the extent to which California's expanding economy is dependent upon forest land for water. Commercial forest and alpine land, we found, produces more than 80 percent of the State's annual streamflow. Nearly 15 percent comes from foothill areas, still largely uncultivated land, growing non-commercial timber, brush, and grass. The figures lend special significance to any management of forest and range lands that influences water flow adversely or beneficially.

In southern California damaging floods followed hard on the heels of the 1953 year-end fires. These gave new impetus to watershed protection in the form of increased fire control in the mountains. A handbook of erosion control for logging areas, prepared jointly by the Station and the Regional Office of the Forest Service, has been in great demand by public and private organizations. The State Department of Fish and Game is trying to improve fish habitat in the North Coast streams by fostering logging practices that will keep the streams clear.

The Station was invited by several groups to discuss the need for research on ways to improve the water yield of California's snowpack lands. All groups evinced interest in the subject, and representatives of several organizations have since urged that research of this kind be started. Although no funds are yet available to the Station for field research, we continued an analysis of snow data obtained by the Central Sierra Snow Laboratory of the Corps of Engineers. The Snow Laboratory was turned over to the Station temporarily when the Corps of Engineers closed it in June. The Laboratory will be available for research in snowpack management if operating funds become available.

The trends toward more diversified and intensive management of forest land noted in 1954 are of considerable significance to a research organization. They serve notice that the demand for information is going to increase rapidly. Improved survey methods will be needed to make resource inventories more accurate and useful. Forest industries will be looking for technological improvements so they can make more use of neglected species, wood residues, and the smaller timber of second-growth forests. Larger investments in managed lands will call for better control of fire and disease and insect pests, better ways to estimate future growth, and more effective ways to keep the land productive. More intensive management will create new opportunities to harvest wood and forage crops in ways that improve the yield of water.

These demands and opportunities put greater responsibility upon research to supply the technical know-how.

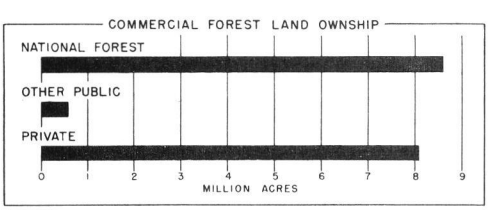
Progress has been made this year in supplying information of this kind, as the results described on the following pages show. The future will require even greater accomplishments.

FOREST ECONOMICS RESEARCH

STATEWIDE INVENTORY OF FORESTS COMPLETE

With the compilation of the report "Forest statistics for California" in 1954, the Station has completed the first intensive survey of the State's timber resource. This project is part of the national program of the Forest Service to obtain current information on the forests of the United States--their area, the volume, condition, and growth of timber, the rate of cutting, and the losses from insects, fire, disease and other causes. The report marks the culmination of several years of field and office work designed by our Forest Survey unit to obtain complete and accurate information for this State. The survey was conducted in cooperation with the California Division of Forestry. Because forests are a living, changing resource, resurveys are planned for subsequent years to keep the inventory up to date.

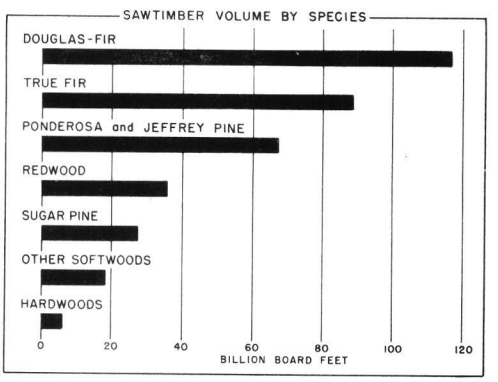
The report points out that 42 million acres, or 42 percent of California's land area is classified as forest. But only 17 million acres are producing or are capable of producing timber of commercial quantity or quality. Most of the 25 million acres of noncommercial forest land is covered with chaparral or a mixed cover of hardwoods and grass chiefly valued for forage and for watershed protection. About 1 million acres are productive forest lands reserved from commercial timber operations in national and state parks and wilderness areas.



The 17 million acres of commercial forest land are confined chiefly to the Sierra Nevada and Coast Range mountains in the central and northern parts of the State. Small patches of commercial timber also occur in the mountain areas of southern California. A little over half of the commercial forest land is in public ownership, chiefly national forests. Most of the private commercial forest land is in industrial and other nonfarm ownerships --timber companies, railroads, recreation areas, and rural homesites. Ranchers and farmers own about one-fifth of the private forest land.

Nearly two-thirds of the commercial forest land (11 million acres) contains old-growth stands of timber, that is, stands of mature timber that have never been cut or partly cut stands which still contain enough mature trees to classify as old growth. Young-growth stands, including areas of small sawtimber, poles, and seedlings and saplings, occupy 4 million acres. Two million acres of commercial forest land have been denuded of commercial conifer species by cutting and fire and are growing only chaparral and poor quality hardwoods.

The volume of standing live sawtimber in the State is 360 billion board feet (International 1/4-inch rule). This is an average volume per acre of 20,800 board feet for the commercial forest land. California is most noted for its pine and redwood timber. But other trees--some all but ignored in previous statewide estimates--are more abundant. Most abundant is Douglas-fir, which makes up nearly one-third of the total, with 117 billion board feet. The volume in true firs (white, red, and grand fir) is 89 billion board feet; this exceeds the volume of ponderosa and Jeffrey pine, which amount to 67 billion board feet. However, if the 27 billion feet of sugar pine is included with ponderosa and Jeffrey pine, the pine volume exceeds that of the true firs. The redwood volume is 36 billion board feet. These 5 species or species groups make up 93 percent of the total volume. The remainder is mostly incense-cedar, lodgepole pine, western white pine, tanoak, and black oak.

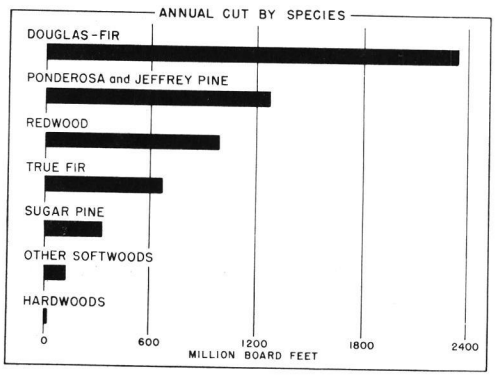


California is still a land of large trees. Forty-one percent of the volume is in trees more than 40 inches in diameter at breast height. Redwood has two-thirds of its volume in trees larger than 40 inches in diameter.

Fifty-four percent (194 billion board feet) of the total timber volume in the State is on public lands. National forests contain 179 billion board feet, and 15 billion feet are held by the Bureau of Land Management, the Indian Service and the State of California.

Net growth on the forests of California is currently 2.9 billion board feet per year. This is an average of 170 board feet per acre. Young-growth sawtimber stands have an

average growth per acre of 322 board feet; old-growth stands, 157 board feet.



The volume of timber cut for all products amounts to 5.2 billion board feet. Lumber is the principal product, accounting for 92 percent of the sawtimber cut. The production of lumber in California has more than doubled since World War II. Production of the other two major products, veneer and pulpwood, has shown even greater increases.

TIMBER PRODUCTION RECORDS COMPILED AND PUBLISHED

To keep abreast of developments in timber production within the State, the Survey staff continued its close cooperation with the Bureau of the Census, the California Division of Forestry, the lumber trade associations, and the timber industries. Although no formal surveys were undertaken, information was compiled on changes in mill location, management, or production, on the development of new plants and products, and on the volume of timber products produced.

Recent trends show that lumber production may have started leveling off after the rapid rise in 1946-1951. The 1952 lumber production of 4.8 billion board feet was about the same as that for 1951. Some segments of the forest industry, however, still show expansion. The production of plywood, pulpwood, and poles and piling was considerably higher in 1952 than in 1950. These and other facts on output of forest products in 1952 are contained in a Forest Survey release published during the year.

OWNERSHIP REPORT ISSUED FOR REDWOOD--DOUGLAS-FIR

Suggestions on how the pattern of land ownership could be modified and pointed toward better land use resulted from a study in the Redwood-Douglas-fir region. This study was made in cooperation with the Agricultural Research Service of the Department of Agriculture. A report published during the year records the development of the ownership pattern since the first settlements and describes the present ownership classes and the land use.

In the heavily timbered redwood belt along the north coast, forest land is held chiefly by large timber companies,

several with holdings exceeding 50,000 acres. In the Douglas-fir belt to the east of the redwood, forest land is intermingled with woodland and grass areas, and timber operations are frequently secondary to ranching. Some large blocks of commercial forest land in this area are in national forest.

In the southern part of the region commercial forest land is interspersed with areas of grass and farm land. Major uses of the land are recreation, residence, and farming. Timber operations usually are secondary and on a small scale. The large urban population of the San Francisco Bay area exerts a strong pressure for small residential and recreational holdings.

The report suggests that the overall pattern of land ownership and use could be improved in three ways: By consolidating ownerships into operating blocks in the redwood belt, by strengthening farm forestry programs in the Douglas-fir belt, and by more orderly planning of the recreational and residential developments in the southern counties.

COOPERATIVE SURVEY MAPS SOIL AND VEGETATION

Basic information needed to improve the management of wild land was collected for half a million acres in northern California during the first year's operation of the reactivated Soil-Vegetation Survey. This project is financed by the State of California and aims to map some 25 million acres of privately-owned range, brush, and timber lands, recording information on the kind and distribution of soils and associated vegetation. The survey is conducted under the general coordinating direction of the Station in cooperation with the California Division of Forestry and the University of California.

The major accomplishments of this first year were fourfold. First, a newly recruited staff was trained and put to work. Second, we prepared a field manual, "Soil-vegetation surveys in California," which describes the methods and standards for the survey. Third, in cooperation with the University Department of Agronomy procedures were developed for a new phase of the project--sampling herbaceous vegetation to help determine the productivity of different kinds of soil for forage. Fourth, survey crews mapped the vegetation and soils of 546,000 acres, distributed among 4 counties as follows:

Tehama	230,000 acres
Glenn	100,000 acres
Lake	130,000 acres
Humboldt	86,000 acres

In Tehama and Glenn Counties the mapping operations are being integrated with a county-wide soil survey that the University already had under way. As a result the University field men as well as those of the Station are mapping both vegetation and soil and to the same specifications in wild land areas. Thus the acreage shown mapped in these counties represents the combined output of the University and Station staff. That shown for Lake and Humboldt Counties was done by Station workers alone.

All field work is now completed in Lake County. This year's mapping by the State cooperative project, plus 435,000 acres mapped before 1953 by the original State-financed project, completed the coverage of all wild lands outside national-forest boundaries. The Station also mapped 35,000 acres for the Forest Service, completing the coverage of Mendocino National Forest within Lake County. Altogether some 804,000 acres have been mapped in the county. Early in 1955 quadrangle maps at a scale of 2 inches to the mile showing the vegetation-soil data will be available for the entire county. Later in the year a county-wide map will be published at a scale of one-half inch to the mile showing soils in color legend.

HUMBOLDT COUNTY PLANS USE OF SOIL-VEGETATION DATA

Humboldt County is getting set to use the soil-vegetation survey information as fast as it becomes available. The Board of Supervisors has set up a Department of Forestry and has appointed a county forester and a 17-man advisory committee representing ranchers, timber owners, lumber manufacturers, and other interests. Recently the Agricultural Extension Service assigned a range specialist to Humboldt County as a farm advisor. He is to work primarily with range and timberland owners. The Agricultural Extension Service in cooperation with the County Department of Forestry is proposing a timber-grassland study and an educational program.

The timber-grassland study would seek to determine among other things which soils are commercially better suited for range purposes, and which for timber. The educational program would acquaint ranch owners with the purpose, method, and results of the soil-vegetation mapping and the timber-grassland study, and help them use the information for more profitable management of their lands.

In addition, forest and range technicians of the California Division of Forestry are working with land owners in the county. These men also will help ranchers in putting soil-vegetation survey data to use.

NATIONAL FORESTS FIND USES FOR SOIL-VEGETATION DATA

Usefulness of this information is being demonstrated by the California Region of the Forest Service, which has contracted for the full-time services of a soil-vegetation specialist on the Station staff. These services have been used by 9 National Forests on 15 different projects. Most of the requests for assistance have been concerned with converting brushland to other types of vegetation, and with road construction projects.

Recent wildfire burns as well as established brush fields are considered for conversion. The soil-vegetation specialist is called upon to classify the dominant soils of such areas and to report their suitability for grass or trees, their erosibility, and other characteristics of significance in land use and management. National forest staff workers use these reports to help decide which areas should be converted to grass, planted to trees, or left as undisturbed watersheds. For example, on one forest five brush fields were investigated for brush conversion possibilities: Only one was recommended as suitable, and based on this recommendation it has been burned and seeded as a demonstration project. On another forest a brush field investigated for conversion was recommended for tree planting. This recommendation was followed, but a portion of the area was planted to grass as an experiment. A later follow-up revealed good tree survival but poor grass growth. On still another forest, study of a large brush field for tree planting possibilities showed that certain parts of the brush field have poor soil for tree growth. Tree planting, therefore, will be restricted to the areas most promising for reforestation.

The use of soil-vegetation survey data on the national forests by engineers in locating and constructing roads is a relatively new development. The vegetation data is used in estimating difficulty and costs of clearing rights-of-way. The soil data provides guides to road surfacing, drainage, slopes of cuts and fills, and grade requirements.

FOREST MANAGEMENT RESEARCH

UNIT AREA CONTROL INCREASES GROWTH IN PINE FORESTS

How the timber harvest should be distributed in applying Unit Area Control to obtain increased growth was shown by analysis of cutting plots in northeastern California. Unit Area Control is a relatively new system of forest management developed by the Station to assure high, sustained production from the timber lands of the California region. The system has

been discussed in a previous annual report, in Forest Research Note 77, and recently in Miscellaneous Paper 16.

As one step in managing the ponderosa-Jeffrey pine type, the overmature timber is harvested by clearcutting the even-aged groups in which overmature trees commonly occur. In this way advance growth is released or unstocked areas are made ready for regeneration activities. To keep cutting cycles short in converting a virgin forest to a managed stand, some of the overmature timber must be carried as reserve. Studies on the Blacks Mountain Experimental Forest show that it is desirable to harvest all the overmature groups within blocks of 5 to 50 or more acres and to carry the reserve on adjoining blocks. In other words, blocks in which all overmature unit areas are harvested alternate with blocks receiving light intermediate cuts.

After the overmature timber has been removed, the only measurable board-foot growth is ingrowth, the volume of poles growing into sawtimber size. To determine the effect of cuting on ingrowth, we studied growth records on a series of 20-acre cutting plots. Some of the plots were selectively cut in varying intensities, others were clearcut. Selective cutting left small groups of adequately stocked pole stands without an overstory. These groups varied from 1/10 acre to several acres in size. Usually trees of older age classes surrounded the borders of each group of poles. Clearcut plots also had adequately stocked pole stands varying from 1/10 to several acres; however, these groups were not bordered by an older age class.

Annual ingrowth per acre was 36 board feet on selectively cut plots, where the pole stands were surrounded by older timber. On clearcut plots the annual ingrowth per acre for the pole stands was 70 board feet. These data strikingly demonstrate that borders of older trees retard the growth of poles.

There are also administrative advantages in concentrating the clearcutting rather than scattering it over the gross area cut. For one thing, timber stand improvement and regeneration can be handled more efficiently because these activities are concentrated on a smaller area. Also, harvesting the remaining overmature timber will be expedited because the gross area covered for each cutting will be reduced. Salvage of future losses will also be easier and less expensive because of the reduction in gross area.

PRUNING HEIGHTS DETERMINED FOR YOUNG-GROWTH PINES

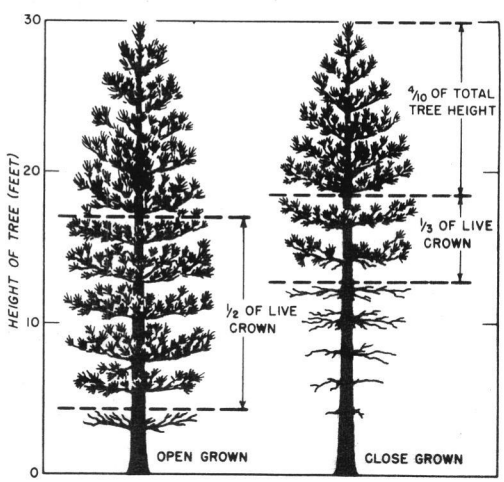
Young-growth ponderosa and Jeffrey pines must be pruned to produce clear wood within a rotation of

140-150 years. Neither of these species normally sheds its lower branches during such rotations. To get the most knot-free lumber then, it is necessary to know how much of the live crown can be removed without serious reduction in the growth rate.

Results of a pruning study on the Blacks Mountain Experimental Forest indicated that up to 50 percent of the live crown can be removed without serious reduction in diameter growth provided at least 40 percent of the total tree height was left in live crown. The diameter growth in inches for the first 5 years after pruning was as follows:

Live crown removed	Diameter growth
None	1.63
1/4	1.68
1/2	1.27
3/4	0.49

At the end of the 5-year period more than half the trees from which three-fourths of the live crown was removed were dead. The growth rate of the trees with half of the live crown removed slowed down at first but was returning to normal at the end of the 5-year period. The growth rate for trees with only one-fourth of the live crown removed showed no significant change after pruning. The pruned trees, growing in an open stand, had crown lengths that averaged 86 percent of the total tree height. Therefore trees having half of their crowns removed still had about 43 percent of the total tree height remaining in live crown.



Amount of live crown that can be removed without serious reduction in diameter growth.

For another test half of the trees were pruned in a thinned, well stocked pole stand. The average diameter growth of the pruned trees was only 4 percent less than on unpruned trees for a 5-year period. Approximately one-fourth of the live crown was removed, leaving about half of the total tree height in green crown. No data are available for more severe pruning

in well stocked stands, but it seems reasonable to assume that pruning will not reduce growth below acceptable levels providing at least four-tenths of the tree height is left in live crown for both open grown and well stocked stands.

In making plans for pruning, it is also desirable to know how high trees of different diameters can be pruned. The height that trees can be pruned will have a bearing on such questions as: When should pruning be started? What should be the upper diameter limit of trees to be pruned? Height curves of crop trees at Blacks Mountain show that open grown trees must average about 14 inches in diameter before a full 16-foot log can be pruned, whereas trees in well stocked stands need be only 9 inches in diameter (table 1).

Because of the difference in pruning height for open grown and close grown trees, it may sometimes be necessary to set different upper diameter limits for trees to be pruned, or not prune complete 16-foot logs on open grown trees. These data clearly show the need for pruning 16-foot logs in two or more operations if pruning is to be started when the trees are still small in diameter.

Table 1.--Pruning heights for crop trees, Blacks Mountain Experimental Forest, 1/ by diameter and by density of stand

D.b.h. (inches)	Crop trees in open stands		Crop trees in closed stands	
	Total height	Pruning height 2/	Total height	Pruning height 2/
	feet			
4	12.0	7.2	16.5	9.9
6	15.5	9.3	22.5	13.5
8	19.5	12.7	28.5	17.1
10	23.0	13.8	34.5	20.7
12	27.0	16.2	40.5	24.3
14	31.0	18.6	46.5	27.9

1/ Site index 70, according to: Meyer, Walter H. 1938. Yield of even-age stands of ponderosa pine. U.S.D.A. Technical Bulletin No. 630. 59 p.

2/ Pruning height when four-tenths or more of the total tree height is left with live crown; however pruning above 18.6 feet is not recommended.

DOUGLAS-FIR REGENERATION LIMITED BY INSECTS AND COMPETING PLANTS

Seed production and dissemination, and changes in ground cover after logging vitally affect the success of forest regeneration. Second year records for clear-cut blocks logged in 1952 in the Douglas-fir type in northwestern California showed that with a rather light seed crop, reproduction was distinctly sparse but well distributed. The records also demonstrated that ground cover conditions changed quickly immediately after logging.

Reduction of mineral-soil seedbed areas is perhaps the most important change. Within 2 years after logging, the ground covered by competing vegetation increased from one-sixth of the total to almost one-half (table 2). Australian fireweed and senecio made large gains. Whipplea and tanoak made only small increases, but these species are widely distributed and may become the most vigorour competitors.

Seedfall information for 1953 was obtained from 173 seed traps distributed evenly over two clear-cut blocks. The cutover tracts were 14.2 and 13.3 acres in size. The traps also sampled a 2-chain strip of timber bordering the logged areas. Seed were scattered reasonably well. The cutovers received 12,000 and

Table 2.--Ground surface conditions on two blocks clearcut in 1952, Six Rivers National Forest, 1953 and 1954 1/

Ground surface	Block A		Block D	
	1953	1954	1953	1954
	-- percent --		-- percent --	
Mineral soil	33	17	35	20
Duff	11	6	16	6
Slash	35	29	23	20
Rocks	3	2	8	6
Vegetation				
Fireweed and senecio	3	17	5	17
Whipplea	5	9	3	5
Tanoak sprouts	7	9	4	6
Other	3	11	6	20
All vegetation	18	46	18	48
Total	100	100	100	100

1/ Basis: Number of milacre plots, Block A, 540; Block D, 124.

17,000 sound seed per acre. Under the timber, traps caught sound seed at the rate of 18,000 and 21,000 per acre. The sound seed amounted to only 19 percent of the total seed caught--a disturbing finding. Seed-damaging insects, probably seed chalcids, caused the high proportion of unsound seed.

The 12,000 seed per acre that fell on one block produced 292 seedlings which lived through the first growing season. On the other block, 476 surviving seedlings resulted from 17,000 seed per acre. By dividing the number of first year seedlings by the number of sound seed, the seedfall efficiency was found to be only 2.4 percent and 2.8 percent for the two blocks, respectively.

Although light seedfall of good seed and low efficiency rates prevailed, the seedlings surviving the first season were well distributed. Evenly distributed 4-milacre plots on the two blocks were 34 percent and 61 percent stocked.

CONE PRODUCTION RELATED TO DUNNING TREE CLASSES

How many seed trees of particular kinds are needed when making harvest cuts for regeneration in the pine region of California? Help in answering this question was obtained from more exact information on cone production in relation to tree classes made available during the year. In an analysis of 16 recorded years, the cone production in relation to Dunning tree-vigor classes has been measured for sugar pine, ponderosa pine, and white fir. The analysis is part of a major study that will soon be ready for publication. Foresters will not be surprised to learn that vigorous trees bear more cones than severely crowded or overtopped trees.

As might be expected, trees in Dunning vigor classes 1, 3, and 5, the dominant trees, were the best cone producers for the three species studied. Trees in classes 2 and 4, the codominant trees, produced only minor amounts of cones. Those in classes 6 and 7, the intermediate and suppressed trees, bore almost no cones. The average number of cones produced per tree on the Stanislaus National Forest during two periods totaling 16 years were as follows:

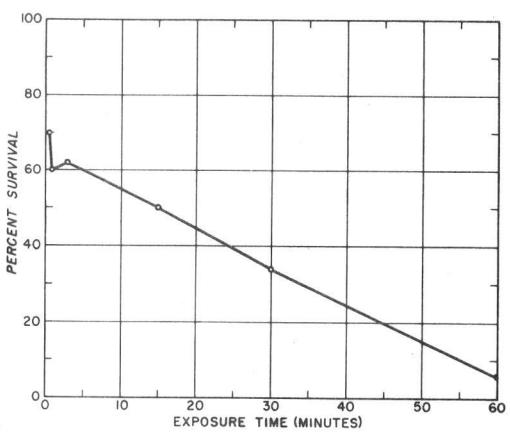
Tree class	Ponderosa pine	Sugar pine	White fir
1	327	45	138
2	23	3	25
3	1,716	555	270
4	39	31	95
5	1,017	712	178
6	1	0	1
7	0	2	0

In considering trees to be left as a seed source for regeneration in the pine region, it may be prudent to harvest most of the class 5 trees and rely mainly on seed from the class 1 and 3 trees. Selection of seed trees should be governed not only by their cone producing ability, but also by the risk of losing them before they can be harvested at a later date. Such factors as spacing, growth rates, and investment value of the trees must also be considered.

ROOT EXPOSURE HARMFUL TO PINE NURSERY STOCK

Handling planting stock in tree nurseries so that it is delivered to the planting site in good condition is always a problem. The amount of root exposure that can be tolerated must be known and excessive drying of roots avoided. Studies just completed showed that a good many trees could withstand a rather surprising amount of air drying. However, even relatively short exposures of 1 to 3 minutes seemed to cause some reduction in survival, and exposure of 15 or more minutes caused severe losses.

The amount of root exposure that can be tolerated by Jeffrey pine planting stock was investigated at the Shasta Nursery. Three-year-old transplants were exposed for six different time periods by spreading them on unshaded boards laid on the ground in the nursery in October on a partly cloudy day. They were then stored over winter and field planted the next spring near the nursery on the Ash Creek Sink Burn on the Shasta-Trinity National Forest.



Effect of root exposure on survival of Jeffrey pine transplants.

STUDIES SEEK TO CONDITION RODENTS TO AVOID TREE SEED

During the past year, Dr. E. W. Jameson, Jr., and Lloyd P. Tevis, Jr., Department of Zoology, University of California at Davis, have continued cooperative forest rodent investigations with the Station on the Six Rivers and Eldorado National Forests. Rodents that eat tree seed are one of the major causes for poor forest regeneration, and current studies are being directed chiefly at developing techniques designed to reduce coniferous seed depredation by rodents. The two more promising methods are aimed at conditioning the rodents to

avoid eating the seed after having associated the ill effects of poison with the seed.

In the first method, poisoned coniferous seed is offered to the rodents as bait before sowing unpoisoned seed for regeneration purposes. The hypothesis being tested here is that the rodents which consume a sub-lethal dose of the poisoned seed will develop "bait-shyness." The rodents then will avoid contact with similar, but unpoisoned seed sown in seed plots.

A second method involves treating seed spots with a highly toxic soil fumigant. Here the hypothesis is that repellent properties of the fumigant will accrue, not necessarily from any unpleasant characteristics of the substance, but from its poisonous effects. Having breathed enough fumigant to become ill, perhaps rodents will subsequently avoid this odor.

BASAL SPRAYS KILL TANOAK SPROUTS

Tanoak sprouts are often an important component of the undesirable vegetation which competes with coniferous reproduction on cutover or burned forest land in the North Coast district of California. A poisoning trial started in 1953 and completed in 1954 showed that tanoak sprout clumps can be eliminated by weak solutions of 2,4-D or 2,4,5-T in diesel oil, applied as basal sprays. However, clumps should be sprayed in the fall to prevent resprouting.

Weak solutions (1.4 percent acid) were applied between July 1 and November 4. All applications killed sprouts effectively. Some resprouting occurred on clumps treated in July and August, but none of the clumps sprayed in October and November. The later dates, therefore, are recommended. The two chemicals gave about the same results, but since 2,4-D is about half as expensive, it is recommended for general use.

YOUNG SUGAR PINES DAMAGED BY FROST

A late spring frost caused considerable damage to young sugar pines in a test planting near Fish Camp in Mariposa County. Minimum temperatures of 27° F. were recorded at the south entrance to Yosemite National Park on the 5th, 6th, and 10th of June. A temperature of about 20° F. probably occurred at the planting site, which was on an exposed ridge about 1,000 feet above the recording station. These heavy frosts occurred after the planted trees had started to grow and after most of the seed sown earlier that spring had germinated.

Frost damaged the new seedlings more than the 3-year-old transplants set out the preceding spring. Seventy-four percent of the seedlings were completely killed by the frost. In

contrast, on 66 percent of the transplants, all or most of the new growth was destroyed, but the trees were still alive in September.

The difference in susceptibility to frost damage between sugar pine and ponderosa pine was most striking. Ponderosa pines, randomly located among the sugar pines, sustained very little frost damage. Only 7 percent of the 2-year-old ponderosa pine transplants were affected by frost, none of which died, and only 9 percent of the seedlings were killed. This difference in frost susceptibility may contribute, in part, to differences in distribution of the two species.

FOREST GENETICS RESEARCH

THREE-WAY HYBRID SHOWS DYNAMICS OF TREE BREEDING

Growth of a new three-species hybrid, in its second year at the Institute of Forest Genetics, illustrates the possibilities for continual improvement of forest trees by applying results of forest genetics research. The hybrid is a cross of ponderosa, Apache, and Montezuma pines. Its history goes back to 1944, when a hybrid between ponderosa and Apache pines was first produced at the Institute.

In many tests since then the ponderosa-apache hybrid has consistently performed according to a definite pattern. At 1 year, it has always been inferior to ponderosa pine in height but superior in stem diameter and in length and abundance of foliage. After 1 year, the hybrid has surpassed ponderosa pine in height growth also, and soon the hybrid's superiority in vegetative vigor is clearly evident. For that reason, we believed that it might be planted for the final crop on some ponderosa pine sites, and the Station has produced hybrid seed for tests on national forests in California.

A few years later, another hybrid, also notable for its vigor of growth, was obtained from crossing ponderosa pine with Montezuma pine of Mexico. This hybrid equaled ponderosa pine in height and diameter at 1 year and then rapidly outgrew it. The ponderosa-Montezuma hybrid seemed even more promising than the ponderosa-Apache hybrid and was given equal prominence in our breeding work.

The excellent performance of these two hybrids suggested the possibility of combining their rapid height and diameter growth. Accordingly the ponderosa-Apache hybrid was crossed with Montezuma pine in 1951. The resulting seed was planted for a 1953 nursery test which also contained tests of three

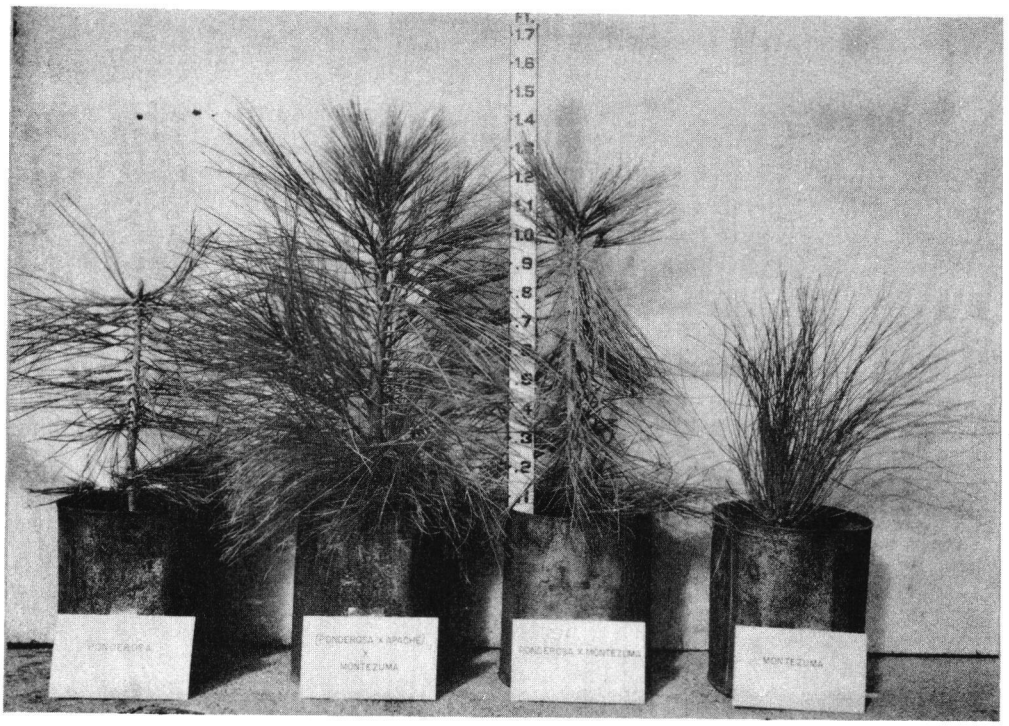
other hybrids: ponderosa-Apache, Apache-Montezuma, and ponderosa-Montezuma. The heights of these crosses and of ponderosa pine, after 1 and 2 years in the nursery, were:

	At 1 year	At 2 years
	(inches)	
Ponderosa pine	3.3	10.0
Ponderosa x Apache	2.5	9.7
Ponderosa x Montezuma	2.9	12.2
Apache x Montezuma	2.2	10.3
Ponderosa x Apache x Montezuma	2.8	14.9

The threeway cross has outgrown the others in height at 2 years, and its diameter at 2 years (0.54 inch) equals that of the ponderosa-Apache hybrid and exceeds that of ponderosa pine by 0.17 inch. Through a series of crossings, we have evidently succeeded in combining exceptional height growth with exceptional early diameter growth. Moreover, the seedlings presumably possess some of the local adaptability of ponderosa pine.

Crosses between these three species can be made in different ways to produce hybrids that are genetically different. The hybrid already produced has 12 chromosomes from Montezuma and 12 others contributed from the chromosome complements of the other 2 species. If more ponderosa pine heredity should be desired in the hybrid, it can be obtained by crossing the Apache-Montezuma cross to ponderosa pine. More of the Apache pine can be attained by crossing the ponderosa-Montezuma hybrid to Apache pine. In this way it should be possible to produce hybrids adapted to different environments. By selecting parents from different parts of their ranges, it may be possible to produce hybrids adapted to environments outside the natural range of parent forms. It may also be possible to add genetic elements of other species, such as Jeffrey pine which crosses directly with both ponderosa and Montezuma pines and indirectly with Apache pine via the Jeffrey-ponderosa hybrid. Finally, additional genetic modifications may be obtained through backcrossing the hybrids to each of the parental species.

This example illustrates the potentialities of synthetic breeding in pines. Elsewhere impressive results have been obtained with other trees, too: birch, larch, and poplar. The dynamic nature of synthetic breeding is analogous to that of industry, which often seems in a race to make its latest products obsolete almost as soon as they are marketed. Each vintage of car, for example, finds extensive use even though it may not be reproduced in succeeding years. Similarly, each improved form or population of pine will be used, but only until surpassed by a superior form or population. In tree breeding as in industry improvement can be a continuous,



Three-species hybrid and other forms at 2 years. Left to right: Ponderosa pine, ponderosa x Apache x Montezuma hybrid, ponderosa x Montezuma hybrid, and Montezuma pine.

outreaching process in which a series of syntheses, such as the three-species hybrid, may result in benefits to several forest regions.

HYBRIDS SHOW PROMISE AS PINE SEED ORCHARD

At present, planting is done on a relatively small scale in the ponderosa pine region, offering an opportunity to increase the use of hybrids little by little. Seed yields from experimental crossings indicate that mass-production of the hybrids of ponderosa pine is possible. The ponderosa-Apache and the ponderosa-Montezuma hybrids can be supplied for planting in gradually increasing quantities until the three-species cross can be produced in abundance. As breeding methods improve and more manpower is devoted to forest tree breeding, the production of hybrid stocks can gradually catch up with regional planting needs. This little-by-little program would not commit forest owners to plant unimproved trees 20 or more years from now, as might be the case if large seed orchards of ponderosa pine were established now.

A small planting at the Institute of Forest Genetics has demonstrated that the hybrids themselves can provide a productive seed orchard. Most pine hybrids are likely to be highly fertile. Also, a large part of the progeny of many hybrids will be better than the weaker parental species, if not better than both parents. Therefore a plantation or forest of a successful hybrid will become a source of valuable seed when the hybrids attain reproductive maturity.

The test of hybrids as seed producers began in 1939. Sixty hybrids between shortleaf and loblolly pines were planted in alternate rows of 15 with shortleaf pines from the same seed tree. After 10 years the hybrids were beginning to suppress the shortleaf pines, and all but one of the shortleaf pines were removed. At that time 65,000 sound seeds were harvested from the hybrids even though some trees had not yet produced seed. Fairly good seed crops were produced in succeeding years. In 1954, 11,500 sound seed were collected from a single tree after squirrels had made a raid on its cones.

This example illustrates the potential importance of plantings of hybrids as seed orchards. Recent reports state that the progeny of the shortleaf-loblolly hybrids have performed well in Iowa. A half pound of seed was shipped to Iowa in 1952 upon request of the Iowa Department of Conservation and another supply of seeds will be forwarded to the Forestry School at Ames early in 1955. If the hybrids continue to prosper there, so that the demand is continued, we shall be able to supply a substantial part of the need from our small planting at Placerville.

NEW BREEDING TRIALS, FIELD TESTS ESTABLISHED

Investivations of rust resistance, inheritance of vigor and form, and self-pollination added to our store of materials from artificial crossing and hybridization in 1954. A total of 345 pollination bags were used in tests that included 37 for rust resistance, 20 for vigor, 40 of tree form, and 13 for self-pollination studies.

Two new first-generation hybrids, certified in the 1954 nursery, were Corsican pine x Japanese black pine and pitch pine x ponderosa pine.

Field tests of various hybrids and other pedigreed stocks were established at the Institute of Forest Genetics, on the Eldorado National Forest, in Tilden Park northeast of Berkeley, and in the desert near Tombstone, Arizona. The Tombstone tests were made in cooperation with the Rocky Mountain Forest Experiment Station and the Newmont Mining Company with

the aid of a grant from the Forest Genetics Research Foundation.

Much of the breeding trials this year were part of the Station's study of selection methods of tree improvement. At present this consists chiefly of a study of the hereditary variation in ponderosa pine. The practical purpose of this study is to find among trees from various localities in the wide range of this species, individuals that are inherently outstanding in growth rate, stem quality, wood quality, and other economically important characters. These superior trees would then be used to produce seed for forest planting in the ponderosa pine region and to provide selected stock for hybridization.

The 1954 trials include crossings between an extremely vigorous ponderosa pine growing on the University of California Blodgett Forest and other, less-vigorous ponderosa pines; between ponderosa pines of good and poor forms, and between ponderosa pines free of, and heavily infested with the western gall rust. Seed was collected from similar crossings made in 1953. Results of these crossings will provide information on the way these characters are inherited and the seeds from controlled pollinations will provide materials for heritability studies. In addition, at a conference with personnel of the Forest Products Laboratory, forest geneticists and other Station workers laid plans for investigating the variation and heritability of anatomical characters affecting wood quality in hybrids and their parental species.

PINE RELATIONSHIPS SHOWN BY BIOCHEMICAL STUDIES

During the past year, the chemical composition of turpentines was determined and published for 12 pine species, including pines native to southeastern U. S., Idaho, Mexico, Nicaragua, and the Philippine Islands. Of particular interest is the fact that the results of some of these determinations support conclusions made by various botanists on other grounds. The chemical composition of the turpentine of Caribbean pine from Nicaragua, for example, differs markedly from that of slash pine of our Southeast. On chemical grounds alone the two deserve status as separate species. This accords with the distinction made between the two forms by E.L. Little, Jr., and K.W. Dorman on the basis of morphological characters. Similarly, our chemical determinations indicate that two Mexican pines, Hartweg's pine and Rudis pine, usually regarded as varieties of Montezuma pine, are actually separate species. This conclusion agrees with the findings of the Mexican botanist, Martinez, and other botanists who studied these pines in their native habitats. Apache pine, regarded by some botanists as a variety of ponderosa pine, likewise is a distinct species on the basis of the composition of its turpentine.

Analyses were made of the turpentines of ponderosa pine trees from Arizona, Colorado, the Black Hills, and Idaho. These analyses revealed chemical features by which ponderosa pines from the Pacific Coast, the Intermountain region, and the region east of the Rocky Mountains can be distinguished. The results of these studies will be of great service in forest genetics and breeding investigations not only in California, but wherever such studies are conducted with pines.

The light cast on pine relationships by the biochemical studies emphasizes the need for basic research in other fields of study. Tree-breeding studies are dependent on flowering and fruiting, and mass production of improved trees for practical purposes is dependent on either flowering or vegetative propagation. Fruiting is highly erratic in pines, and little is known about the biology of seed production. Therefore we are unable to stimulate or regulate flowering and fruiting. Most pines can be rooted from cuttings, but methods for rooting pines on a commercial scale have yet to be developed. Basic research is the most promising approach for the removal of these obstacles to more rapid progress in forest tree improvement.

FOREST FIRE RESEARCH

FIRE AGENCIES JOIN IN OPERATION FIRESTOP

Wild-land fires that occur during severe burning conditions, and those that result from many simultaneous ignitions over a large area, frequently develop into fires that cannot be extinguished by existing fire-fighting techniques and equipment. Mass fires of this nature account for more than 90 percent of all wild-land fire damage. The control problems and behavior of these fires are identical with those of conflagrations which result from incendiary and atomic attack in urban areas.

Fire services in California this year united in a one-year test program designed to explore certain aspects of these problems. Called "Operation Firestop," this program sought new information on mass-fire behavior, and made tests aimed at providing the fire services with some new aids for mass-fire prevention and control. Federal and state civil defense agencies and several branches of the Department of Defense also joined in the program. A large part of the Station's work in forest fire research during 1954 was devoted to this cooperative project. To make the fire research staff available for the project, it was necessary to suspend or severely curtail activity in other fire studies.

The field program of Firestop included some basic studies in fire behavior and forest fuels. Another phase of the project was a wind survey, aimed at adding to the existing store of information on research procedures and instrumentation. This information will help set up a long-range program of surveys of wind patterns in the major drainages of California. At Firestop, surface weather data were recorded at 22 weather stations and from anemometers hanging from cables across canyons in a selected drainage in the test area. Air soundings of temperature, humidity, and wind were made from ground level to 20,000 feet. Analysis will be completed in 1955.

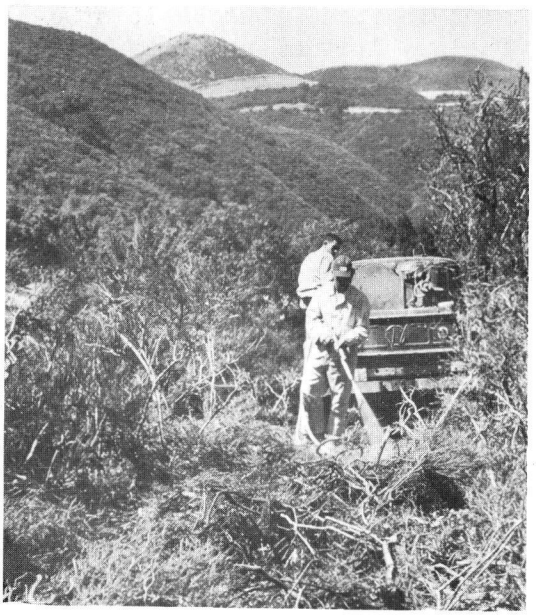
Major emphasis of the field program was placed on exploratory studies that could have immediate application to fire control problems. Analysis of the data has not been completed, but preliminary results of some of these studies in which Station personnel participated contain much information of value to fire fighters.

CHEMICALS PROVE HELPFUL IN FOREST FIRE FIGHTING

Fire-retardant chemicals were tested by applying them to unburned fuels and letting fire run into the treated areas. Field tests showed that some readily available chemicals could be used effectively this way for several fire-control purposes. Rate of spread and intensity of the head of a fire could be materially reduced; crown fires in heavy brush could be made to drop out of the crowns. Chemicals might be used to protect cleared control lines from sudden, hot "runs" of fire. Also, chemical may permit use of narrower fire-control lines under some conditions.

Fire lines made simply by applying fire-retardant chemicals successfully stopped the rear and flanks of fires in grass and light brush fuels. Chemical lines which can be put in quickly in the lighter fuels can thus be used for backfiring purposes.

In the heavier brush fuels a new technique for rapid fire-line construction was developed. First, a bulldozer with the blade raised smashed the brush to let men and equipment through. Then the smashed brush was treated with chemicals and immediately used as a firing line. Smouldering ground fires may creep across a line cleared this way, but the method provides a means of establishing a fire line in critical situations in a fraction of the time required for conventional clearing methods. Moreover, only a very small follow-up crew with hand tools was needed to put out lingering spots of fire along the lines cleared this way in the test program.



Brush smashed by bulldozer is sprayed with chemicals to create a fire-retardant line.

Other chemicals which increase the ease of ignition and burning rate were studied as aids to backfiring. These chemicals are of two kinds: Foliage desiccants and fuel additives. The desiccants include some herbicides and some materials used to defoliate agricultural plants. Tests showed that 2 to 4 hours after green brush foliage was sprayed with desiccants, its moisture content was reduced enough to increase inflammability of the brush materially. The fuel additive tested was diesel oil. Spraying brush with this material made effective backfiring possible when it was otherwise difficult to get a fire to burn. Night and early morning backfiring, particularly, which are often impossible because of poor burning conditions, may thus be facilitated using either or both of these chemicals.

AIRCRAFT SPEED APPLICATION OF CHEMICALS AND WATER

Since speed of application is often the critical factor in determining whether chemical and water treatments are practical, applying them from the air was tested. It was demonstrated that fixed-wing aircraft equipped with ordinary agricultural spray equipment may be used effectively in rough terrain for spraying both desiccant chemicals and fuel additives.

Aircraft were studied as possible means for speeding the application of water on the fire line. A torpedo bomber was rigged to drop 600 gallons of water or chemicals from its bomb bay. This unit can thoroughly drench an area 50 feet wide and 270 feet long. The most promise for use of this type of attack appears to be in slowing down or holding spot fires or critical sections of a fire until ground forces can carry out effective suppression action. The tests demonstrated that aircraft suitable for this type of work in mountain terrain must combine high payload capacity with good maneuverability.

Helicopters, too, were tested for fast transporation of water to the fire line. Helicopters like Bell's 47 and Hiller's

Aircraft were valuable fire-fighting aids at FIRESTOP field tests. Torpedo bomber, top, accurately drenched small areas with 500 gallons of water dropped from special bomb bay tanks. Small helicopters, lower left, quickly pulled as much as 400 feet of lightweight hose over rough terrain. "Helitanker" unit, lower right, delivered 100 gallons of water, 300 feet of hose, and a small pump to any spot on the fire line.

12B or larger can carry live-reel hose charged with water 200 to 300 feet from tankers in a matter of seconds. They can also lay up to 1,000 feet of 1-1/2 inch cotton-jacket hose from trays carried beneath the helicopter faster than a pumper can charge the hose with water.

An important development in the use of the helicopter is the "helitanker." This unit is made up of a 100-gallon tank, a small lightweight pump, and 300 feet of hose. It can be picked up from a truck or ground and delivered to nearly any place on the fire line.

BACKFIRING MADE EASY FROM THE AIR

Getting backfires to burn away from, and thus widen, the fire line often presents fire fighters with a difficult problem. The area ignition technique of firing--starting many scattered fires at once--was tested as one possible solution. Starting numerous fires in the vegetation for considerable distances back from the fire line was demonstrated to be a practical way to get backfires to burn under some difficult situations. This technique did speed the backfiring job.

Although these scattered fires can often be started from the ground, tests showed that helicopters can be used effectively to set backfires in areas not readily accessible by other means. After the scattered fires are started, the helicopter can be used to fan them to speed burning--and to some extent even control the direction of burn.

FIRE-DANGER RATING REVISED

The system of fire-danger rating used by the national forests in California is revised from time to time to permit more precise estimates of fire behavior. Revision is usually done when a more refined system is needed in planning fire-control expenditures and fire-control strategy. A refinement completed in 1954 brings additional fire-behavior factors into the danger rating system. These include the effects of differences in annual precipitation and the effects of cumulative drying of fuels during the fire season.

Procedures for adjusting estimated fuel moisture in different forest types have been reworked. New tables and forms have been developed to use more fully existing information on the effects of seasonal precipitation, stage of vegetative growth, moisture content of indicator sticks, and relative humidity.

The revised system will be ready for use on California national forests during the 1955 fire season.

CALIFORNIA AGENCIES STUDY LIGHTNING RESEARCH PROJECT

Several California agencies joined this past year in a review of the possibilities of learning more about lightning storms in cooperation with the Intermountain Forest and Range Experiment Station and the Munitalp Foundation. These two agencies are conducting a cooperative project called SKYFIRE. It studies cloud formation and behavior as a first step in acquiring knowledge that may help develop ways to reduce lightning occurrence through cloud modification. The cooperating agencies in California included National Forest Administration, the State Division of Forestry, the U. S. Weather Bureau, and the Station.

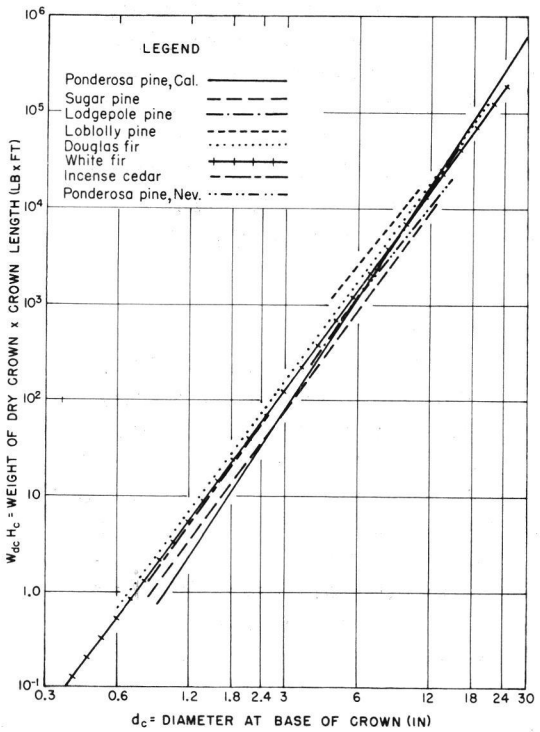
Eight fire lookouts were selected as cloud observers here this year. Observations covered about a 2-month period. The data were compiled by the California Division of Forestry and the Station and then transmitted to Western Fire Weather Coordinator, Ralph Hanna for analysis. The virtual absence of lightning storms in the study area during the observation period resulted in a poor yield of useful information. The cooperating group in California concluded that for continuation of the study here, more cloud observation points are needed, thorough training of observers is essential, one or more full-time field supervisors are necessary, and analysis of information collected would be a major project.

SPECIAL PROJECT CONTINUES TO YIELD BASIC KNOWLEDGE

Investigations being conducted by a special-project staff at the Station include fundamental research on the convection column of a fire burning in the free atmosphere and on the breakage of trees by wind storms.

A smoke column is generally visible when a fire burns. This smoke is associated with a convection column within which combustion products and heated air are transported upward, inducing an indraft at the ground. When surface winds are gentle, fire-induced indrafts are the main source of oxygen supply for combustion. The strength of the convection column, then, is dependent on meteorological conditions and the heat liberated by the fire; there is an interaction between the fire and the behavior of its smoke column. A theoretical analysis has been completed which describes the behavior of the convection column under zero surface winds. The behavior of the column under the influence of surface winds is also under theoretical analysis. The objective of theoretical attack is to establish relationships which will guide contemplated experimental investigations. These results, in turn, will provide quantitative measures of fire behavior based on fundamental principles of heat transfer and chemistry of combustion of solid fuels.

Investigation of crown and stem characteristics of conifers was one of several studies of the problem of tree breakage due to wind. Curves were produced which permit close estimation of the weight of dry crown and branchwood foliage for 13 species when the crown length and the stem diameter at the base of the crown are known. The curves show: (a) relative crown weight and tolerance are not necessarily correlated; (b) weight changes more rapidly with stem size for certain species; (c) relationship varies by site for ponderosa pine. Analysis indicates certain species-site groupings are advisable for estimating purposes. Results can be used by the forest manager to predict the amount of slash that will be produced under different cutting methods. For example, estimating curves prepared in this analysis show that the crown of a single large ponderosa pine may produce as much as three tons of dry slash (table 3). Data were obtained so that the crown weight can be estimated when only diameter at breast height is known, rather than diameter at crown and length of crown, with only a small loss in accuracy.



Relationship between dry crown weight times length and stem diameter, selected species.

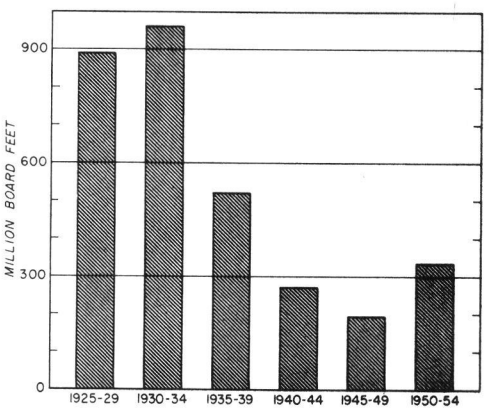
Table 3.--Dry crown weights for selected stem diameters and crown heights, for California ponderosa pine

Stem dia. at base of crown (inches)	Height of crown	Weight of dry crown
	feet	pounds
4	15	17
8	30	130
12	50	390
16	60	1,010
20	70	2,070
24	80	3,700
28	90	6,020

FOREST INSECT RESEARCH

DAMAGE BY FOREST INSECTS RISES SLIGHTLY IN 1954

Insect-caused damage to California forest resources in 1954 is estimated to be slightly higher than in 1953. The level of damage is low, as such losses go, but even so the stumpage value of the timber killed in 1954 is about 18.3 million dollars. As usual, tree-killing bark beetles, especially those infesting pine, accounted for most of the damage. One noteworthy change in the insect situation this year was the occurrence of an outbreak of the Douglas-fir beetle over a 200,000-acre area in northwestern California. Here, the Douglas-fir beetle has destroyed more than 100 million board feet of old-growth Douglas-fir timber. Direct control of the beetle is not feasible, but foresters in the area are revising their cutting plans to permit salvage of killed timber as soon as possible.



Pine timber killed by bark beetles in California, 5-year averages 1925-1954.

In Yosemite National Park, where a serious infestation of the lodgepole needle miner occurred in 1953 on about 45,000 acres, the mountain pine beetle has reappeared. The beetle is in epidemic numbers in stands weakened by repeated needle miner defoliation. In the past, concurrent outbreaks of these two insects in the same stand have destroyed extensive acreages of lodgepole in the Park. This latest epidemic probably will follow the same pattern; the result will be further destruction of a considerable area of old-growth lodgepole in Yosemite in the next few years. Satisfactory methods for controlling the needle miner have not been developed, and control of the mountain pine beetle in these high Sierra stands is difficult and costly.

Elsewhere in the State, the fir engraver caused heavy scattered losses throughout the range of white fir. The pine bark beetles caused sporadic losses throughout the pine belt, but no widespread outbreaks occurred. Bark-beetle losses in southern California decreased considerably, chiefly because of the steady effort in the past 2 years to suppress the more serious outbreaks. Several potentially important forest defoliators were observed, including the spruce budworm,

white-fir sawfly, silver-spotted Halisidota, and Oslar's tussock moth, but none of these insects caused serious damage.

The California Forest Pest Control Action Council met with members of the Station in early November to review the status of current pest problems and the control program proposed for 1955. The Station and the California Division of Forestry are cooperating in the preparation of a report of forest insect conditions in California for 1954, which will appear early in 1955 under the sponsorship of the Council.

RESIDUAL-TYPE SPRAYS DIFFER IN TOXICITY TO BARK BEETLES

Certain insecticides like DDT sprays, are effective chiefly because the element that is toxic to insects is left behind as a residue after the carrier liquid in which the chemical is dissolved has evaporated. Insecticides that act in this manner are called residual-type sprays. These sprays offer the most promise of providing a solution to two urgent bark-beetle control problems in California: the need for a relatively inexpensive insecticide that will kill bark beetles in infested trees or logs, and the need for an insecticide that will prevent bark-beetle attacks on trees of high value. There are good possibilities for developing formulations of residual-type insecticides and techniques for using them that are effective against bark beetles. Moreover, there is reason to believe that such insecticides will prove to be considerably cheaper and easier to use than other methods.

Research on residual-type sprays for bark-beetle control has been in progress 3 years. Many residual insecticides are in use against agricultural and other pests, and one of our first jobs was to learn how toxic the most widely used materials are to the more important bark beetles. A standardized technique for screening candidate insecticides has been developed. Using this technique, toxicity indices have been established for DDT, toxaphene, lindane, and isodrin, in tests with the western pine beetle and the California five-spined engraver. In descending order, the relative toxicity of these materials is: To western pine beetle -- isodrin, lindane, DDT, toxaphene; to California five-spined engraver -- lindane, isodrin, DDT, toxaphene.

All four insecticides were found to be much more toxic to the engraver than to the western pine beetle. Isodrin was two times as toxic, DDT 4, toxaphene 9, and lindane 14. Median lethal doses (LD 50, micrograms per milligram of body weight) and the relative potency of each insecticide, using DDT as the standard in each case, are as follows:

Toxicant	Western pine beetle LD 50	Western pine beetle Relative potency	California five-spined engraver LD 50	California five-spined engraver Relative potency
DDT	0.095	1.00	0.024	1.00
Toxaphene	0.428	0.22	0.049	0.48
Lindane	0.034	2.67	0.002	9.83
Isodrin	0.019	4.99	0.008	2.84

It is premature to conclude that these insecticides will have the same relative effectiveness under field conditions. Factors not yet studied may profoundly affect their efficiency, such as absorption into the bark, size, shape, and distribution of residue particles, and weathering qualities. This work does show, however, that there are basic differences in the ability of residual insecticides to kill bark beetles, and that the western pine beetle and pine engraver do not react alike to the same chemical.

BARK BEETLE RESISTANCE STUDIED IN PINES

The ability of pines to resist attack by insects has been under study by the Station for several years. It has been commonly observed that most pines attacked by bark beetles exude oleoresin at each point of attack. Consequently, we have given a good deal of attention to the kind and quantity of oleoresin produced, since it appears that this is important in determining the success or failure of attacks.

Between different kinds of pines, qualitative differences in oleoresin are probably highly important in determining which species of bark beetles can successfully attack a tree. Within a given species of pine, however, the composition of oleoresin is known to be relatively uniform, but the amount that a tree produces and the time of flow are variable. One point to learn was whether the amount and duration of flow in ponderosa pine were correlated with risk ratings, which are indicative of susceptibility to bark-beetle attack. Oleoresin flow rate was measured on trees at the Blacks Mountain Experimental Forest. Trees rated highly susceptible to bark-beetle attack, we found, produced about the same amount of oleoresin as those rated of low susceptibility. Duration of flow, however, was significantly different. Low risk trees continued to produce oleoresin 5 to 8 days after flow started, whereas the flow from the high risk trees stopped on the second or third day.

In young-growth ponderosa pine on the North Warner Mountains, Modoc National Forest, we found evidence that host

resistance may protect certain stands from complete destruction by the mountain pine beetle. Outbreaks of the beetle in these stands frequently kill trees in groups, but some trees in the groups survive. The amount of oleoresin produced by surviving trees was found to be far greater than the amount from trees that died. This finding confirms observations made repeatedly in the field that in trees where bark-beetle attacks are "pitched out," abnormally large pitch tubes are formed at each point of entry.

Development of better knowledge of the factors that enable trees to resist attack has two benefits. It enhances our chances of breeding resistant trees. And it provides an opportunity to improve present stands as we become better able to recognize and weed out susceptible trees.

VIRUSES CONTROL SOME INSECT PESTS

Insects, like many higher forms of animal life, have their own complement of parasites, predators, and diseases. These biotic control agents help keep the population of a given insect from overrunning the universe. If we completely understood how biotic factors work, it is quite conceivable that we could do much to improve their effectiveness. Then we could use them to combat some of our important forest insect pests.

The possibility of using insect diseases to control insects that kill trees by consuming the foliage appears to be especially promising. For this reason the Station has given special attention to disease organisms in studies of two defoliators -- the lodgepole needle miner, a pest of lodgepole pine in Yosemite National Park, and the white-fir sawfly, a pest of white fir throughout the central and northern part of the State. The Department of Biological Control, University of California, has cooperated in this work.

In studies on the lodgepole needle miner, neither disease organisms nor parasites and predators appear so far to be outstanding as natural control agents. Most of the needle miner population has been found to be infected by a granulosis virus, discovered by Canadian workers in 1950. But this virus seems to kill only a small part of the population. The needle miner is host to more than 25 different species of parasites, but little is known of their habits or their importance. Biotic control factors thus far have not been successful in curbing the needle miner outbreak in Yosemite National Park.

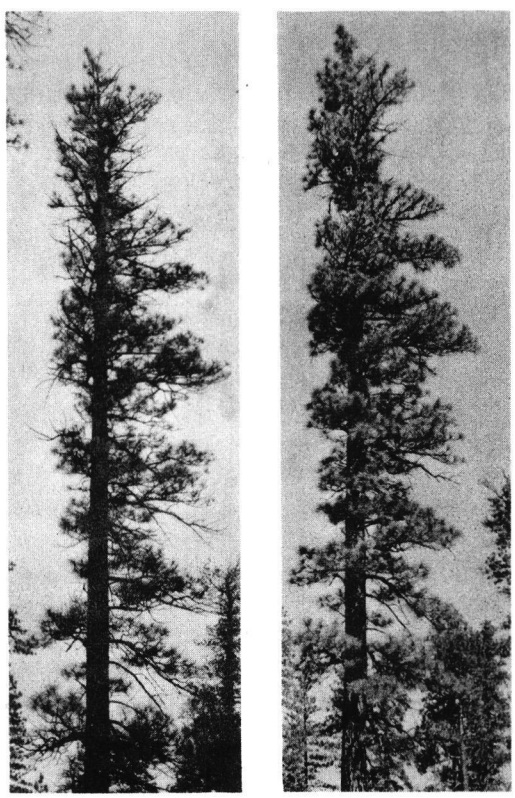
The white-fir sawfly, however, is undoubtedly regulated to a considerable extent by biotic factors. This was discovered in 1953, when it was found that most of the sawfly population was infected with a native polyhedrosis virus. The virus killed many of the sawfly larvae before they could mature. The discovery was made after an unsuccessful attempt to use a virus of the European pine sawfly imported from the east as a control agent. The native virus caused great reductions in the sawfly populations in 1953 and 1954. It does not act quickly enough to prevent considerable defoliation because the larvae do not succumb until they are nearly mature. The white-fir sawfly also is attacked by many parasites and predators, but these organisms do not seem able to reduce the sawfly population greatly.

PHOTOGRAPHS RECORD CHANGES IN RISK CLASS

Studies of risk classes, developed to rate the susceptibility of ponderosa pine to attack by bark beetles, were continued in 1954. In the 17 years since this concept of rating tree susceptibility was developed, the usefulness of the risk classification has been repeatedly demonstrated. In addition, the standards used in rating trees have been refined and some information gathered on their reliability.

Some light on the question has been shed by a study in which changes in a series of ponderosa pine trees on the Blacks Mountain Experimental Forest were recorded photographically. Forty-eight trees, representing all risk classes, were photographed from the same camera stations in 1940 and 1953. Between times 11 of the trees, all classified as high risk, were killed by bark beetles. Four trees were felled. For the 32 trees that lived, analyses completed in 1954

Crown conditions indicative of this tree's susceptibility to bark beetle attack changed for the better in the past 13 years.



1940 1953

show that in 27, representing all risk classes, the condition of the crown improved, in 3 it remained about the same, and in 2 it was worse at the end of the 13-year period. Several factors may have had a part in improving the condition of the majority of the trees that survived. Of these factors, a general increase in seasonal precipitation during the past decade probably was the most important.

INSECT DAMAGE ASSESSED IN CONES AND SEEDS

It has been known for many years that cones and seeds of forest trees are hosts to several different insects. Failure to secure satisfactory forest regeneration in areas logged during good seed years probably can often be traced to destruction of the seed supply by insects. Some of these pests feed directly upon the seed; others feed upon the flowers or young cones with the result that the seed does not mature. The more common cone and seed insects have been studied to some extent, but little quantitative information has been obtained as to the amount of destruction that they cause.

This year the Station made a survey of the Douglas-fir and sugar pine seed crop to find out how much seed was destroyed by cone and seed insects. Personnel on seven of the national forests in northern California participated in this study. The average amount of the Douglas-fir seed crop destroyed for all national forests sampled was 82.2 percent. For sugar pine, the average was 75.1 percent. Forest by forest, the percent of the crop lost averaged:

National forest	Douglas-fir	Sugar pine
Six Rivers	91.6	--
Klamath	97.8	78.1
Mendocino	87.7	50.1
Shasta-Trinity	71.6	31.8
Lassen	53.2	69.1
Stanislaus	--	85.4
Plumas	--	92.7

The principal pest of sugar pine cones is the sugar-pine cone beetle. This beetle mines throughout the interior of the immature cone, preventing the seed from developing. The Douglas-fir seed crop is attacked by several species of moths, among which the Douglas-fir cone moth, the fir dioryctria, and the fir geometrid are probably the most important. Another important pest of this tree is the Douglas-fir seed chalcid. Methods for controlling these pests have not been worked out.

FOREST DISEASE RESEARCH

TIMBER LOSS FROM ROT ESTIMATED FOR STATE

Joint efforts by Station pathologists and the Forest Survey have made available the first comprehensive figures on the amount of cull from decay in the forests of California. Out of the total volume of merchantable coniferous timber in the State, 12.7 percent, or more than 51 billion board feet, have been rendered unusable by decay. Besides this about 23 billion board feet of conifers are too rotten to be logged, and 5 billion board feet are cull in hardwoods. Altogether 79 billion board feet have been lost from rot in the forests, enough, if sound, to run all of the sawmills of the State for about 16 years at the present rate of cutting.

Incense-cedar, with a cull percent of 36, is the most defective of the major forest species, and redwood is next, with 22 percent cull. Other species in which cull is relatively high are Douglas-fir and white fir. Ponderosa and Jeffrey pines, with only 3 percent cull, are the least defective.

These cull figures emphasize that when the timber situation in California is considered as a whole, decay constitutes a major source of loss. To date, cutting has taken place for the most part in the least defective species, such as the pines, or in the better and less defective stands of species with higher average cull, but this cannot continue indefinitely. As sound timber becomes scarcer or more remote, loggers must turn to the more defective stands. Profitable logging in these stands may well depend on how much knowledge of cull indicators is applied in marking felled trees for bucking into logs. Cull hauled to the mill and sound material left in the woods are both expensive. Getting the most out of defective timber at the least cost is not a job for untrained woodsworkers but requires special on-the-job training or the services of a specially trained man.

It will be many years before all trees with active decay fungi in the heartwood can be cut. How fast will decay progress in the meantime? Here we lack information on the environmental conditions within the tree, such as temperature and oxygen content, that influence the rate of growth of individual decay fungi in heartwood and the amount of resultant decay. A full knowledge of the effects of these conditions would undoubtedly aid us to understand why decay is so much heavier in some locations than in others. Looking to the future,

we need to find out how to log and manage our timber to avoid the development of rot as far as possible. In growing forests it does not pay to grow rot.

DETERIORATION RATES LEARNED FOR FIRE-KILLED TIMBER

Reliable guides on the rate at which fire-killed trees decay have been worked out to aid foresters and salvage loggers. Forest fires may kill more than 250 million board feet of timber in the principal commercial timber stands of California during a severe fire season, such as 1951. The wood in the killed trees is usually not damaged by the fires, and no loss in merchantability is suffered if the killed timber is promptly logged. But planning, road building, and other preliminaries to the start of logging require time. Also, the logging job on a large burn can seldom be completed within a single season. Therefore the degree to which fire-killed timber of merchantable size can be profitably salvaged depends on when deterioration starts in the wood of the dead trees and how fast it progresses.

To learn what time is available for salvage, we felled and dissected fire-killed trees of 5 different coniferous species on 16 different burns in California. We found that both fungi and insects play a part in deterioration, and they usually work together. Some fungi produce only limited deterioration, such as blue stain or sap stain, which lowers but does not destroy the value of the wood for lumber. The stain is confined almost entirely to the sapwood of killed trees.

Fungi that cause decay render wood completely unmerchantable for lumber. Three species of decay fungi, the red-belt fungus, the pouch fungus, and the purple fungus, were found to cause most of the loss in merchantability of fire-killed timber in California. Sapwood decays more readily than heartwood but the difference is greater in some tree species than in others. Decay progresses much more slowly into the heartwood of sugar pine and Douglas-fir than into that of white fir or of ponderosa and Jeffrey pines.

Little deterioration occurs during the first year. In pine some degrade from blue stain is suffered, and a small amount of incipient decay develops in white fir. By the end of the second year most of the sapwood has become cull, so that small trees and those with wide sapwood are unmerchantable. White fir often becomes unmerchantable by the end of the second year. Large sugar pine and Douglas-fir

trees may remain merchantable for many years. Complete findings from the deterioration study will be presented in a Department of Agriculture publication.

SPRAYS FAIL TO CONTROL PINE NEEDLE DISEASE

Attempts to control a needle disease on ponderosa and Jeffrey pines with fungicidal sprays have failed. The blight--Elytroderma needle disease, the most important one of its kind in the West--has heavily infected young timber near Lake Tahoe. Once established, the fungus causing the disease often persists year after year, causing the infected foliage to turn red in the spring and severely weakening heavily affected trees. We had hoped that the sprays would prevent reinfection and permit recovery of the diseased stands.

Several types of fungicides were selected for trial and were applied in water solution early in the fall by means of a commercial-type power sprayer. The first applications were made in 1952. The tests were repeated, with additions and increased concentrations, in 1953. Materials tested in 1952 were phenyl mercury ammonium lactate, a copper-zinc formulation, captan, ziram, and Bordeaux mixture. In 1953 the ziram and Bordeaux mixture were omitted and a polymerized sulphur formulation and a summer oil, together with a mixture of captan and polymerized sulphur, were added to the schedule. None resulted in any visible control of the disease in either year.

Concurrent experiments, in which infection from fall spores was prevented by placing bags over twigs, indicate that failure of the sprays was traceable to the timing of the infection. New needles probably were infected not in the fall, as all previous evidence had indicated, but earlier in the season before the fall spores matured. Before trying further spray experiments, it will be necessary to determine when infection occurs; this problem is being studied by research workers in other regions where the disease is more damaging.

ROOT DISEASE CONTROLLED IN GENETICS ARBORETUM

A few years ago a destructive native root fungus, Fomes annosus, became established in a block of stone pines in the arboretum of the Institute of Forest Genetics. The fungus gradually spread. By the time the disease was recognized, it had killed two pines, had damaged a Douglas-fir in an adjacent border planting so severely that it was attacked by bark beetles, and was established in the root systems of other neighboring trees. If unchecked, the disease promised ultimately to ruin much of the arboretum, which probably

contains the best living collection of pine species in the world and is a major source of materials used by Station geneticists in tree-breeding experiments.

For control, Station pathologists recommended that carbon disulphide be tried as a soil fumigant. This chemical is used with considerable success in the control of oak root fungus in orchards in California. Before treatment, the apparent boundaries of the infected area were explored by ditching and several extensions were found to be necessary to include all of the area invaded by the fungus. In the spring, after the ground temperature had reached favorable levels, the fumigant was applied by means of a hand injector. The ground surface then was sprinkled to provide a water blanket for retaining the gas formed by evaporation of the fumigant. Subsequent attempts to isolate the causal fungus from formerly-infected roots within the treated area have failed. The treatment appears to have been successful in halting the disease. So far as known, this is the first instance in which carbon disulphide has been employed for control of the annosus root fungus.

RUST FOUND CAUSE OF PINE KILLING

In one part of northern California, thousands of ponderosa pines have been killed or their tops killed out in recent years through the gradual girdling of the trunk at various distances above ground. Locally the damage was ascribed to rodents because of signs of rodent gnawing in connection with the girdling. Forest tree-disease specialists, however, saw evidence of a slowly-spreading canker. They reasoned that an organism causing the canker made the affected bark attractive to rodents, but the identity of the organism remained in doubt. A rust was suspected but no fruiting material could be found.

Finally, after considerable search, a strip of live inner bark at the edge of a canker was found which had not been chewed off by rodents. On the bark a rust was forming spores; it proved to be comandra blister rust, a virulent but sporadic disease of ponderosa pine. Subsequent checking in the area confirmed the rust as the cause of the cankers. The alternate host for this rust is an inconspicuous perennial herb that is now scarce there. No young rust infections were found and the present killing is from infections established more than 40 years ago. Losses from established cankers which have not yet caused complete girdling will continue over the next 20 to 30 years.

BLISTER RUST INFECTIONS DATED IN SUGAR PINE

White pine blister rust, the chief threat to sugar pine in California, enters the tree through the needles. In western white pine in northwestern United States, most infections take place through 1-year-old needles. Blister rust scouts have used this fact to determine the probable age of establishment of newly-found rust centers in white pine. However, scouts operating in California found indications that the proportions of infections entering through needles of different ages here might be different than for white pine to the north.

Station forest disease specialists checked this possibility, using data on blister rust cankers in locations where the year of infection was definitely known. They found that on sugar pine in California 1-year-old needles are still the most susceptible, but about twice as many infections take place through needles of the current year as in the Northwest. Probable explanation: infection takes place later in the season in California than in the Northwest. Consequently current season's needles are physiologically more mature here, and they are more nearly like 1-year-old needles in susceptibility.

FOREST UTILIZATION SERVICE

FOREST INDUSTRIES CONTINUE HIGH PRODUCTION LEVELS

Forest products output continued at a high level during 1954, the lumber cut being near the 5 billion board-foot mark of the past few years. The plywood industry of the state continued to expand; 3 new plywood plants and 4 new veneer plants came into production during the year.

One of the new plywood plants is in southern California and another is near the lower end of San Francisco Bay. Two of the new veneer plants were established in the interior of the Coast Range of northern California, an area which until recently was accessible only over rough, narrow roads. New sawmills have been set up in this area, and veneer logs are being hauled to plants on the coast and in the Sacramento Valley. Hauling distances are 115 to 120 miles. This coast range area contains a large volume of timber, mostly Douglas-fir. It has been opened to operations only since the mid-1940's, and more roads are needed to reach much of the area where large volumes of inaccessible timber await utilization.

Production did not change significantly between species during the year. Markets held up to the point that production of all woods has been well maintained. Some improvement was made in methods of manufacture and preparation of white fir for the market, encouraging the hope that white fir will become firmly established in the trade and will maintain its position.

WOOD RESIDUES FURNISH MATERIAL FOR FIBER PLANTS

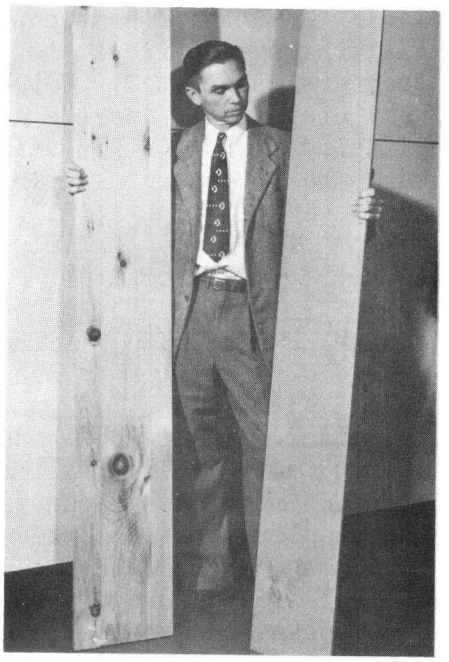
Many inquiries have come to the Station from companies interested in wood supplies for manufacturing fiber products. Both logs and plant residues are being considered for conversion into fiber. Already a good deal of plant residues is being used for fiber production in the California region, but the volume is only a small part of the volume of slabs, edgings, and trimmings developed in manufacturing lumber and plywood products. We estimate roughly that enough unused residues are developed in the State each year to supply fifteen 250-ton pulp mills. In several parts of the State sawmills and plywood plants develop enough wood residues suitable for fiber use to permit concentration at a reasonable transportation cost. Log debarkers, both mechanical and hydraulic, have been installed at several sawmills in the pine and redwood regions, making possible the production of bark-free chips from much of their slabs and edgings.

Besides the solid wood residues, large quantities of shavings and sawdust are produced. Technological developments may make these materials useful in the manufacture of building board or chemicals. A few operators strategically located are now marketing shavings and sawdust for livestock bedding and soil improvement, but the amount is small compared with the volume still unused. Some sawdust is also being used for molding purposes in the Los Angeles area.

PAPER OVERLAYS DEVELOPED FOR WOOD BOXES AND LUMBER

Development of paper-covered veneer has stimulated increased interest in this material for lightweight, low-cost containers to be used in shipping agricultural products. Four companies are now actively working in this field. Tests are underway at the Forest Products Laboratory in Madison, Wisconsin, on the nailing of thin sawed box material, particularly of white fir and on the practicability of types of fasteners other than conventional nails. This work has not progressed to the point where a report is available. It is felt that boxes of lighter weight and lower cost can be made if better fastening methods can be developed. Anything learned about such fasteners may also be applicable, in part at least, to the fabrication of containers using veneer for sides and bottoms.

Another paper-overlay development may be of considerable interest to lumber manufacturers in the State. Specially treated paper overlays are being applied on selected types of common lumber to provide good appearance and good painting qualities. The usefulness and the value of the lumber may be increased considerably by the overlays. Experimental work is now being carried on at the Forest Products Laboratory on the practicability of applying such overlays to ponderosa pine and white fir containing various types and sizes of knots and other defects.



White pine before and after overlaying with resin-treated paper.

CALIFORNIA HARDWOODS RECEIVE GREATER USE

The utilization of California hardwoods has progressed slowly during 1954, but there are encouraging signs that they will come into their own as economic conditions become more favorable. California has large supplies of redwood, pine, Douglas-fir, and true firs that are more attractive than hardwoods to loggers and mill men. The big production effort is therefore aimed at the large-scale operations possible in softwoods. Nevertheless, some new uses of hardwoods were started.

One company installed a 12-foot veneer slicer, and we understand they plan to produce hardwood veneer. Tanoak, madrone, chinkapin, and California laurel are available. Of these the laurel appears the most promising at present. Another company recently started production of black oak veneer 1/8-inch thick by 9 inches square, for use as flooring. These squares are applied with mastic directly on a concrete or plywood sub-floor, as asphalt or rubber tile is applied. The veneer is surprisingly smooth and tight. This floor covering is being sold principally through the Los Angeles market.

Results of seasoning studies indicate the hardwoods will be more difficult to season than the softwoods with which they are associated. Seasoning of black oak is now fairly well understood, and the seasoning should not now be the limiting factor in its utilization. A small quantity of the hardwoods is being used in the manufacture of novelties, and some lumber is cut at mills for specialty uses or on a trial basis. There is still no extensive production of hardwood lumber or cut-stock.

BETTER LUMBER SEASONING IMPROVES USE OF WOOD

There appears to be a growing awareness of the potential savings or potential losses that can be effected by good or poor lumber seasoning practices. Kiln operators at many of the larger mills are taking their rightful position of importance along with sawmill and remanufacturing plant supervisors. Better utilization of forest products through good seasoning is primarily a matter of more skillful manipulation of the dry kilns and air drying yards. At least six "special seasoning methods" have caused a stir of interest in the industry during the year, but none has found industry approval.

Dry kiln clubs continue to be effective in promoting better lumber seasoning. Three clubs operate wholly within the State, and one draws members from mills in southern Oregon and northern California. All four have carried on energetic programs. The general pattern of the meetings includes an inspection, or "show-me" trip, of the host company's facilities and a technical meeting. During the technical meeting different phases of lumber drying are discussed by members and often by guest speakers. Twenty-six meetings were held during the year with an attendance of approximately 750 men.

Meetings of dry kiln clubs are a very effective method of wholesaling information on seasoning that comes to us from the Forest Products Laboratory in Madison and from other research centers. The free exchange of ideas among kiln operators and other operating personnel at these meetings is a positive influence for improving lumber seasoning throughout the industry.

SPECIAL KILN STUDIES TO AID MANUFACTURERS

In manufacturing pencil slats, it has long been the standard practice to hold the 3-inch incense-cedar plank on the air-drying yard for many months before processing. This practice required carrying large inventories of planks. To see if the need can be avoided, the Station is cooperating

with one of the pencil slat manufacturers to determine the practicability of kiln drying the green 3-inch plank. A small experimental lumber dry kiln (500 board feet capacity), obtained from the Forest Products Laboratory several years ago and used in studies of drying California black oak, is being used in the current study. Preliminary results indicate that kiln drying of unsegregated planks will be difficult, but that the lighter, lower moisture content stock can be dried green-from-the-saw. High moisture content or "sinker" stock is difficult to kiln dry, but a combination of air drying followed by kiln drying may be satisfactory and reduce the time and amount of raw material held in inventory.

The Forest Products Laboratory has undertaken a field survey of commercial kiln drying practices for softwoods, aimed at improving the schedules now recommended in laboratory reports. A preliminary survey of the pine industry in California indicates that some plants with virtually the same type of drying equipment use greatly different drying schedules. Apparently, the nature of the lumber in different sections of the pine region justify some differences in the schedules used. Some operators, however, apparently use milder schedules than are necessary, and the survey, when completed, should be beneficial in improving the kiln drying practices at some mills and in reducing drying costs.

STUDY EFFECT ON GROWTH ON PROPERTIES OF WOOD

Last year's report mentioned a study of the properties of the wood in young-growth ponderosa pine from the west side of the Sierra Nevada, begun at the Forest Products Laboratory. The objective is to determine what effect site, degree of stocking, and related factors may have on the physical properties of the wood. Several years ago the Laboratory began studies of the structure and properties of wood from hybrids produced at the Institute of Forest Genetics. This work will compare the wood of hybrid progeny with that of the parent species.

Close coordination of studies of this type was planned during a field meeting of Station and Laboratory workers in 1954. Those on the field trip were representatives of the Forest Products Laboratory and the Station's Forest Genetics and Forest Management research divisions and Forest Utilization Service unit. They examined several areas of young-growth timber and land of different site quality. As our studies in forest genetics and young-growth management progress, we plan to draw the Forest Products Laboratory into the work so as to know more precisely what quality of wood is being produced.

RESISTANCE TO EARTHQUAKES TESTED IN WOOD STRUCTURES

A study of design of earthquake-resistant wood diaphragms for walls, floors, and roofs is being completed at the Forest Products Laboratory. This research project is of particular interest to structural engineers of California, the building industry, and suppliers of lumber. The study is a cooperative job between the Forest Products Laboratory, the California State Division of Architecture, and the Corps of Engineers. It included tests of several designs of full-size wood framed and sheathed wall and floor and roof panels or diaphragms. The State of California has been especially interested because of its large current and pending school construction program. Although the final report is not yet available, it is evident that the tests show where weaknesses in present designs occur. The tests also point out the improvements that result from proper design and reinforcement of weak points. The work is of great importance to all concerned, particularly in view of the large building program being carried out in the State and the safety hazards in improperly designed buildings during earthquakes.

RANGE MANAGEMENT RESEARCH

CHANGES MADE IN STATION RANGE RESEARCH PROGRAM

As a result of reorganization of the Department of Agriculture, the Station range program now consists chiefly of studies of brushland improvement, grazing management, and the restoration of good browse plants on depleted game ranges. The last project is handled in cooperation with the State of California.

At the San Joaquin Experimental Range, the grazing trials with weaner steers on fertilized range are being continued as a cooperative effort between the Forest Service, Agricultural Research Service, and University of California. Results from these trials during the dry-forage period, winter period, and green-forage period of the year were analyzed and the first draft of a report was completed. Lisle R. Green, who was in charge of the studies before accepting an appointment at California State Polytechnic College on January 1, 1955, will be senior author of the report. Other authors will be K. A. Wagnon, Department of Animal Husbandry, University of California, and J. R. Bentley, California Forest and Range Experiment Station.

NEW TECHNIQUES HELPFUL IN BRUSH BURNING

Special ignition devices show promise for judicious brush burning on range lands. Exploratory study of the devices for spring burning in chamise-chaparral was conducted during the past year in cooperation with the University of California and the Mendocino National Forest.

The objective was to develop methods for burning out wide strips of brush at strategic locations in the terrain, particularly on steep lateral ridges. The strips break up the brushfields, improve deer and livestock range, and facilitate control of wild fire. Attempts to burn the strips by conventional hand-setting of the fire during the spring usually resulted in spotty burning and considerable wasted effort. Weather conditions were seldom favorable at the time when workmen were on the ground.

The limited trials of 1954 indicate that effective burning can be done during dry weather in early spring by simultaneous firing at many points along a ridge. The firing was accomplished by locating grenades in accumulations of fuel prepared by slashing and piling brush. The grenades, spaced at intervals of 50 to 100 feet along a 1/4-mile line, were fired by electrical circuits or by fast fuse. Hot fires that could be easily controlled under springtime conditions were generated along the entire length of the area included in each test. A design for location of slashed lines and individual sets was developed for further trial. This kind of burning appears to be economically feasible and will be used next year on a larger scale on the Mendocino National Forest.

SOIL TEMPERATURE RECORDED DURING BRUSH BURNING

Physical appearance of the ground surface on each part of a burn on woodland range is a good indicator of the soil temperatures which occurred during burning. This relationship was shown by analysis of records from 44 pyrometer stations set out in a controlled burn at the San Joaquin Experimental Range. A specially designed pyrometer was used in this study to determine the depth at which several critical temperatures occurred under different kinds of fuels. After the fire, the ground surface at each pyrometer station was classified according to its appearance as: Grass-burn; brush-burn, black-ash; brush-burn, bare-soil; or brush-burn, white-ash.

We found that each class had a typical curve of heat penetration. This curve proved to be related to the amount of natural seed remaining after the fire and to the depth to which organic matter was charred or incinerated in the soil. Therefore, the four ground surface classes provided reliable guides to seedbed condition for artificial reseeding.

Grass-burn seedbeds are recognized by charred remains of herbaceous cover. Temperatures considered sufficiently high to destroy seed of most herbaceous species do not penetrate through the litter, or if litter is absent do not penetrate into mineral soil. Surviving seed is adequate for a full stand of annual plants.

A grass burn is a poor seedbed for artificial reseeding, mainly because of the competing plants that will grow from unburned seeds.

The three brush-burn seedbeds occur where fire in stands of trees or shrubs has been sufficiently hot to kill the stems and branches of the vegetation.

Black-ash seedbeds usually have charred leaf litter remaining on the soil surface. Charring of organic matter extends slightly into mineral soil. Temperatures in the litter and at the soil surface are above 350° F. during burning. Most seed of annual species are destroyed. The seedbed is suitable for broadcast sowing of improved forage species, but without seeding the ground usually will be covered by natural revegetation in two or three years.

Bare-soil seedbeds have most or all of the litter incinerated. Charring of organic matter extends 0.5 to 1.0 inch into mineral soil. Temperatures of 350° F. or higher occur to this depth. Few seeds of annual species survive. This is an excellent seedbed, and artificial reseeding is necessary for a satisfactory plant cover.

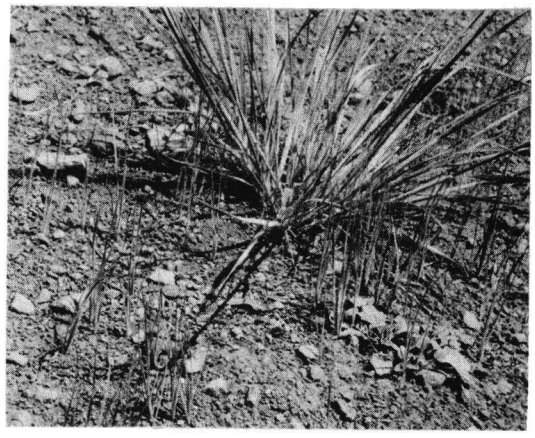
White-ash seedbeds usually have a layer of white ash on the soil surface immediately after the fire. A light colored zone of mineral soil in which organic matter has been incinerated occurs to depths of 0.25 to 0.5 inch or deeper, with a charred zone below. Temperatures of 600° F. or much higher occur in the mineral soil. All seed is destroyed; artificial reseeding should be done.

White ash is usually conspicuous after the fire. By the time for sowing grass seed, however, the ash has either disappeared or covers only a very small portion of the burn. The most reliable indicator of the need for artificial revegetation, then, is the depth to which organic matter in the soil was charred during the fire.

SEEDLING ESTABLISHMENT STARTS IMPROVEMENT OF MOUNTAIN RANGE

Improvement of native bunchgrass range by application of a new grazing plan has been started in a northeastern California test. Abundant seedlings of desirable native forage species--mainly perennial bunchgrasses--were obtained directly as a result of the plan. As these seedlings grow to full size in the next 4 or 5 years, they will increase forage and therefore the livestock production capacity of the range. The grazing plan was designed to encourage seedling establishment at regular intervals, for seedlings are the key to maintenance of grazing capacity at peak levels year after year.

This plan, tentatively called the 5-unit grazing system, was developed at the Burgess Spring Experimental Range from 1936 to 1951. The current test is being conducted on the Harvey Valley range allotment of the Lassen National Forest. This allotment is 32,352 acres in size and is grazed by 500 head of cattle from June 1 to October 1.



Abundant seedlings show range is improving under new grazing plan.

The grazing system calls for subdivision of the range into 5 units, some of which are rested and others grazed in rotation over a 5-year cycle. The key provision in the system is for rest periods during which the range has a chance to recover production capacity. The rest periods are geared to the growth requirements of the key forage species. Aims of the rest periods are: To restore vigor to grazed plants, to encourage seed production, and to aid in establishment of seedings.

The third year of testing in Harvey Valley was completed in 1954. During this season, the first of the five allotment units was brought to the seedling production stage. From now on a different unit will reach this stage each year. This test will be carried on for several more years. A reasonably good check on the improvement to be realized from the grazing plan can be obtained by 1963 when each of the range units will have received 2 complete cycles of grazing treatments.

The first measurements designed to bring out changes in range condition and production capacity were made during the past season. The principal specific factors being measured are: Vegetation, including density, yield, species composition, seedling production, and utilization; soil erosion and soil condition; and livestock weights and condition.

TEST INCLUDES MANAGEMENT OF ARTIFICIALLY RESEEDED GRASS

The effect of the five-unit grazing plan on the establishment and efficient use of forage produced by cultural means such as artificial reseeding, chemical spraying, water spreading, and drainage improvement is also being studied on the Harvey Valley allotment.

Since the start of the grazing test in 1951, several areas on the allotment were reseeded with introduced grasses, or sprayed with 2,4-D to release native bunchgrasses from sagebrush competition, as follows:

Year and season	Treatment	Acreage
1951		
Fall	Reseeding, smooth bromegrass	132
Fall	Reseeding, crested wheatgrass and smooth bromegrass	25
1952		
Spring	Spraying 2,4-D on big sagebrush	1,700
Fall	Reseeding, intermediate wheatgrass	74
1953		
Spring	Reseeding, smooth bromegrass and crested wheatgrass mixture	106
Fall	Reseeding, intermediate wheatgrass	48
Fall	Reseeding, crested wheatgrass and mountain bromegrass mixture	23
1954		
Spring	Spraying 2,4-D on sagebrush	100
Fall	Reseeding, smooth bromegrass	42
Fall	Reseeding, tall wheatgrass	9

Satisfactory initial seedling and forage stands were obtained in all cases. Only stands from reseeding and spraying in 1951 and 1952 have been grazed so far, and these for only a half season--August 1 to September 30, 1953 and 1954. First appraisals of the reactions of these stands to grazing management will be made in 1955.

NEW METHOD SPEEDS BITTERBRUSH GERMINATION

A new method of obtaining quick germination of bitterbrush seed was perfected in 1954. Dormancy in the seed was overcome by soaking in a 3 percent solution of thiourea. High germination, from 70 to 90 percent, was obtained even after the treated seeds were air dried and then stored at room temperatures for several months.

The new process opens the way for spring planting with dry seed. Heretofore, seeds for spring planting were obtained by stratification. This method resulted in wet seed that was very difficult to handle during stratification and during planting in the field.

This new finding came from a study in progress since mid-1952 to develop methods for artificial reseeding of browse plants on deer winter ranges in the semi-arid eastside region of California. This is a Pittman-Robertson Federal Aid project in which the Station is cooperating with the California Department of Fish and Game. Primary emphasis has been placed on developing methods of reseeding bitterbrush--the most important deer winter browse on eastside ranges.

The main objective of the work to date has been to determine the factors that are important for successful reseeding.

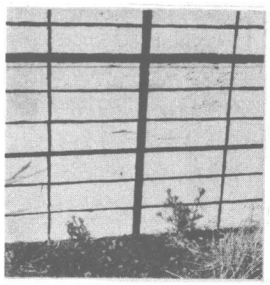
Some of the factors that have been found to be important to date are:

(a) Knowledge of seed germination.
(b) Evaluation of site--to determine suitability of the site for particular species.
(c) Site preparation--reducing vegetation that competes with browse plants for moisture.
(d) Time and depth of planting.
(e) Rodent control--to prevent destruction of browse seed and seedling.

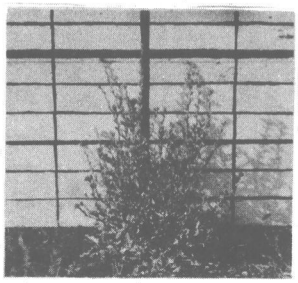
Burning, disking, and chemical spraying are three "tools" being tested for use in preparing sites for planting. Results of the first 2 years showed clearly that existing vegetation on planting sites must be reduced to insure survival and maximum growth of seedlings obtained by artificial seeding. Burning in spring or summer was effective in controlling cheatgrass where enough fuel was present to create a hot burn. Of the several chemicals tested, Dalapon, CMU, and IPC (CL) gave good results on cheatgrass. About 90 percent reduction of cheatgrass and about 75 percent reduction of other annual weeds were obtained. Both fall and spring disking effectively reduced sagebrush and perennial grasses and eliminated enough annuals to permit the establishment of reasonably good stands of bitterbrush seedlings on suitable sites.

Even in the second year of development of bitterbrush seedlings, plant competition has stunted growth and caused some seedlings to die. Plants under heavy competition grew only about 1 inch in height during the second year and reached an average maximum height of only 2.8 inches, whereas plants under light competition grew about 8 inches in the second year and reached an average maximum height of nearly 14 inches.

BITTERBRUSH SEEDLINGS
2 YEARS OLD



HEAVY COMPETITION



MEDIUM COMPETITION

NEGLIGIBLE COMPETITION

Under heavy competition, from 3.3 to 8.8 percent of the seedlings died in the second year, whereas under light competition mortality was negligible -- 0.7 percent on one plot and 1 percent on two others. In the first year, mortality was about 20 percent under light competition and 30 to 45 percent under heavy.

These results again point to the need for careful site preparation before planting; reduction of plant competition is absolutely necessary for high survival and good growth of seedlings.

Rodents have taken from 48 to 87 percent of the bitterbrush seeds in some small-scale experimental plantings. This loss indicates the possible need for rodent control on large-scale plantings. During the summer censuses were made on several experimental areas to determine the kinds of rodents present. Moderate to high populations of kangaroo rats, pocket mice, white-footed deer mice, chipmunks, golden-mantle squirrels, and pack rats were found. This information is being used to formulate rodent control measures on planting sites.

The first attempt to seed bitterbrush on a fairly large scale was made this summer on two wild burns in the sagebrush type in Lassen County. A total of 33 acres was planted. Three areas were drilled and one broadcast and rolled with a cultipacker. A poison bait was distributed on part of the acreage to control rodents. This project, proposed by the California Department of Fish and Game, was carried out cooperatively with that Department, the U. S. Fish and Wildlife Service, the Bureau of Land Management, and the Plumas National Forest.

Early in the year an advisory committee was formed to guide the browse research project. Representatives from organizations interested in game-range restoration in California accepted membership. Their first field meeting was held at Flukey Spring in Modoc County on October 6. There they had an opportunity to see first-hand the deer winter range problems affecting both California and Oregon and the research in progress at Flukey Spring on artificial reseeding of browse species.

WATERSHED MANAGEMENT RESEARCH

WATER-YIELDING AREAS DELINEATED

Most of the water flowing in California streams comes from the wild lands of the State. A study made this year showed where the water-yielding lands lie, classified them in belts or zones according to type of cover and precipitation, and determined the average annual water yield of each. This knowledge of where our water comes from will help in planning watershed management research because the water-yielding zones differ in opportunities and methods of managing the land for water control.

California's average annual streamflow totals about 71 million acre-feet. Ninety-five percent of this amount is yielded by 42 percent of the State's area, that which receives an average annual rainfall of at least 20 inches. The main water-yielding area can be divided into four parts, each of which has broadly different watershed management implications.

The brush-woodland-grass belt, which lies mostly below 2,500 feet elevation, covers some 17,850,000 acres and yields about 8,930,000 acre-feet of water each year. Acre-for-acre this foothill land yields less water than the land at higher elevations. But muddy surface runoff from the foothills entering clear streams from the high country can lower water quality and increase flood damage. Primary emphasis of watershed management in the foothill belt should therefore be on the control of surface runoff and erosion.

Another of the major water-yielding areas of the State is the forest belt below the snowpack line. It covers 12,530,000 acres and contributes 22,550,000 acre-feet, or 32 percent of the State's water. Here logging, grazing, and other land uses should give primary attention to erosion control so that water quality is not impaired. But because rainfall is high in this belt, it may also be possible to manage the land in ways that will increase water yield without adversely affecting water flow.

There are two other water-yielding areas. Both of these are in the snowpack zone, which has been defined as the zone in which streamflow is fed mainly by snowmelt. It lies above elevations of about 5,000 feet in the central and southern Sierra Nevada and above 3,500 feet around the head of the Sacramento Valley. The land below this zone yields most of its water to streams in winter and spring. The snowpack zone is the mainstay of streamflow into the dry summer and fall. Its 12,500,000 acres yield an average of 36,200,000 acre-feet of water a year, 51 percent of the State's streamflow.

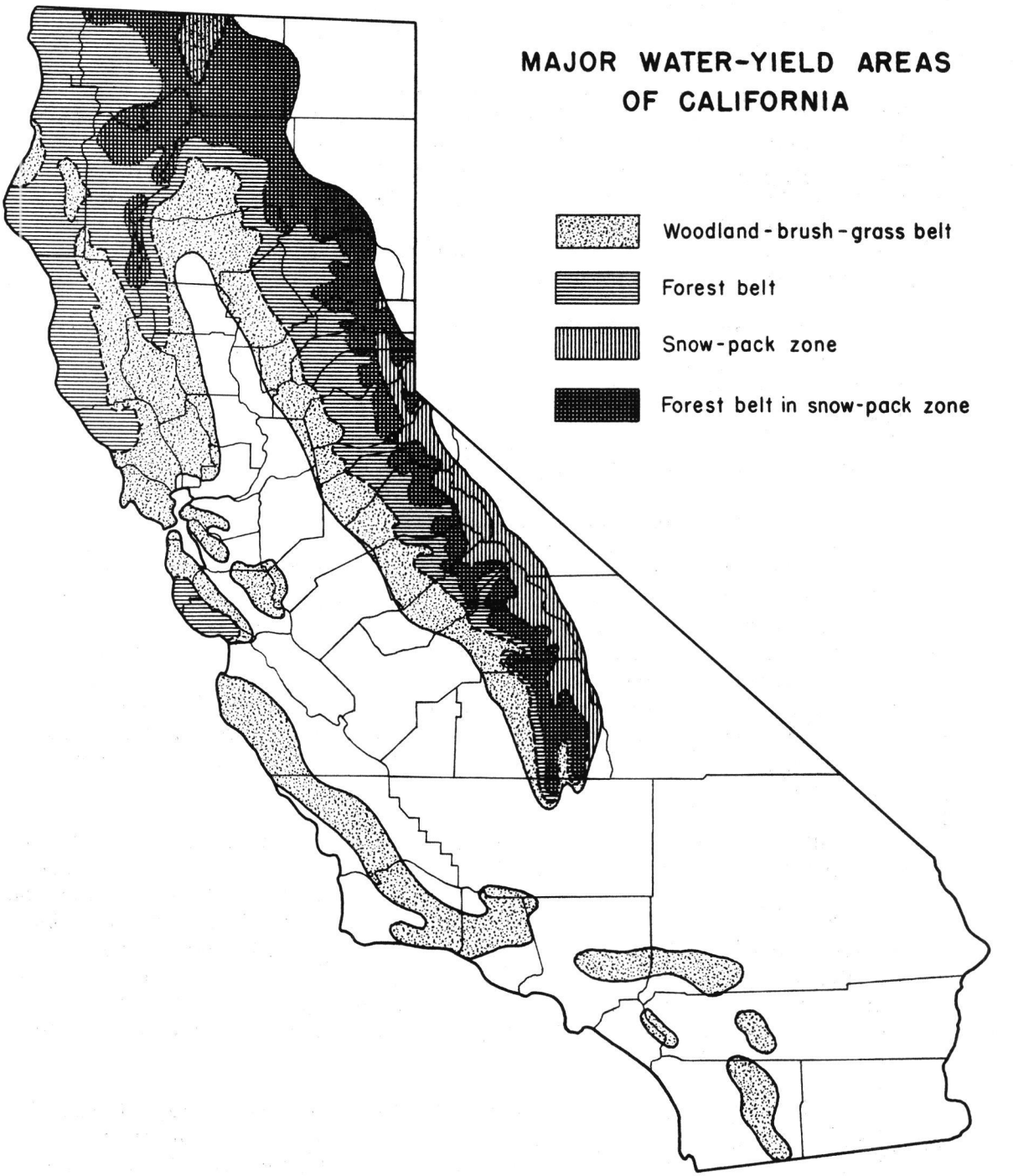
The upper 3 million acres of the snowpack zone is alpine land which will probably be held primarily as primitive areas for recreation. Here land management offers relatively little chance to affect water yield. The lower-elevation snowpack area, however, offers important opportunities for watershed management. The 9,070,000 acres in this part of the snowpack zone yield 27,200,000 acre-feet of water a year, 38 percent of the State's water. Logging is moving upward in the virgin forests of this area, and forest management offers a chance for significant improvement in water yield if practicable forest treatments are developed by which snowmelt can be slowed and the water yield of the snowpack increased.

SNOW ACCUMULATION AND MELT INFLUENCED BY FOREST CONDITIONS

Analysis of snowpack and forest data collected by the Corps of Engineers near Soda Springs provided some information this year on how forest shade and other shielding influence the water yield of snow.

Two snowpack characteristics were studied. One was the maximum accumulation of water in the snowpack, expressed as the water equivalent of the pack on April 1. The other was the rate of depletion of the snowpack after April 1. The analysis covered three years (1949, 1950, and 1951) and used data from 5 snow courses with 5 snow sampling points in each. The sampling points covered a wide range in forest conditions. The forest cover at each point was characterized by two variables which represented the shade effect of trees just south of the sampling point and the shielding effect of the trees north of the point.

The study brought out that maximum April 1 snowpack occurs where shade is 73 percent, and there are no trees to the north. On the average, 11 inches less snowpack water was found under a dense forest than in large openings. Field observations indicated that this difference was the net result of differences in drifting, melt, and evaporation from the snowpack before April 1. The magnitudes of these various effects have not been determined.



	Area (Acres)	Av. ann. water yield (Acre feet)
Woodland-brush-grass	17,850,000	8,930,000
Forest belt below snow zone	12,530,000	22,550,000
Forest belt in snow zone	9,070,000	27,200,000
Alpine snow zone	3,000,000	9,000,000
Total	42,450,000	67,680,000
Entire State	101,300,000	71,000,000

Rate of snow melting after April 1 was strikingly influenced by forest cover. The melt rate decreased progressively with both increase in shade and increase in tree height or nearness of trees to the north. Shade had 8 times as much effect as nearness of trees to the north in reducing snowmelt. The melt rate in a dense forest was 55 percent of the rate in large openings, those with no shade and with trees no closer on the north side than 3 times their height.

The net result of forest cover on snow accumulation and melt was determined by combining results of the two analyses. Whereas there was 11 inches more snowpack water in the large openings than in the dense forest on April 1, the excess was only 7.4 inches on May 1. By June 1 the dense forest had 6.5 inches more snow water than the large openings. On June 6, when the snow finally disappeared from the large openings, the forest snowpack still contained 10.6 inches of water.

In another analysis we found that snow melted more slowly in small forest openings than in dense forest. Results of this analysis suggested that if a dense forest were cut in east-west strips, maximum storage of snow water would be found in cutover strips whose width was 40 percent of the average tree height. The average amount of snowpack water in such strips on this date would exceed that in a similar dense forest by 8 inches and that in a large opening by more than 18 inches in an average year at this location.

MAJOR BRUSHLAND AREAS MAPPED AND DEFINED

How much land in the foothill areas of California is covered with dense shrub and tree growth, commonly called brush? This question is often asked because the brush interferes with land use, and thus creates problems in land management, over a considerable area of the State. Graziers want better forage for livestock; wildlife managers want better habitat for game; and water users want to maintain the type of watershed cover that is best for water yield and erosion control.

To answer the question the Station produced a map of the area, using Forest Survey data, and prepared a description of the brushy cover types. The map showed that the brushland problem area covers about 20 million acres, of which 9 million are occupied by woodland types and 11 million by chaparral and associated types. The problem brushlands are found in the Coast Ranges and on the west side of the Cascade-Sierra Nevada Range below the commercial timber belt. The map and type descriptions were released by the Station as Miscellaneous Paper No. 15.

Two important uses have already been made of the published material. A colored version of the map was used in the University of California film "Hills of Grass." More recently, the map was reproduced in the California Division of Forestry bulletin "Costs and Returns of Controlled Brush Burning for Range Improvement in Northern California", by Arthur W. Sampson and L. T. Burcham. The authors used the acreage figures as a basis for their estimate of 9 million acres as the maximum area in which brush control for range improvement may be feasible.

EFFECT OF WATERSHED FIRE ON STREAMFLOW MEASURED

In 1953 about 170,000 acres of mountain land in southern California were burned over by wildfires. Two large storms in January 1954 brought extremely damaging flood flows from several of the burned areas. Millions of dollars worth of damage occurred below the mountain front from Sierra Madre to San Bernardino. Valuable storage space was lost by sedimentation in reservoirs and flood-ways. Homes were destroyed and other properties covered with debris.

We had a unique opportunity this year to measure the effects of fire upon streamflow during storms because one of the fires burned into the San Dimas Experimental Forest. One-third of Wolfskill Canyon (Watershed I), which has an area of 1,525 acres, was burned-over in December. This watershed had not been burned for at least 50 years before, and detailed streamflow records had been obtained there for 17 years before the 1953 fire.

In January 1954, 3 storms brought a total of 13.86 inches of rain to the partially burned watershed. The first storm was small and produced negligible streamflow. Six inches of rain fell in each of the second and third storms. Rates of 0.64 and 0.79 inches an hour were maintained for 1-hour periods, and rates of 1.32 and 2.52 inches per hour for 5-minute periods.

The second post-fire storm produced high and abnormal runoff at the streamgaging station at the mouth of the watershed. The stream, which had been flowing clear water at about 0.1 cubic foot per second (c.f.s.) before the storm, increased to a torrent of more than 40 c.f.s. after 2.7 inches of rain had fallen. This flow was bulked with mud, rocks, and fire debris. The peak was a sudden surge of water 6-1/2 feet deep as it passed through the 10-foot-wide streamgaging section--a flow of 1,025 c.f.s. composed of water, mud, rocks, and logs. The flood wave dropped shortly to 700 c.f.s. and 17 minutes later to 200 c.f.s. The high flows left a 4-foot boulder in the streamgaging flume and many other large boulders in its entrance.

Flows of similar nature but smaller size occurred during the third storm and in later storms that year. Meanwhile in other watersheds of the Experimental Forest undamaged by fire, streamflow peaks had been moderate and the flows clear.

To determine how much the burn in Wolfskill Canyon had increased peak flows and total flows during the January storms, streamflow records from this watershed were compared with those from the upper East Fork of San Dimas Canyon (Watershed III), which has been unburned for at least 50 years. Watershed III, though slightly smaller than Watershed I, is similar to it in aspect and elevation, and the vegetation of both canyons was similar before the 1953 fire. First we compared peak flows from the two watersheds before and after the fire. We found that if Watershed I had not been damaged by fire, its peak flows would have been 3.36 c.f.s. per square mile during the first 6-inch storm and 10.46 c.f.s. per square mile during the second. The measured peak flows were 429 and 297 c.f.s. per square mile. Hence the peak flow of the first storm was 128 times as great as, and the second storm 28 times as great as would have been expected had Watershed I not been partially burned.

Next we compared total streamflow during the storms; we found that Watershed I, if unburned, would have discharged 6.09 acre-feet of water per square mile during the first large storm and 10.95 acre-feet per square mile during the second. The measured flows were 31.4 and 32.9 acre-feet per square mile. Thus total flow from the fire-damaged watershed was 5.2 times as great as expected during the first storm and 3.0 times as great during the second storm.

SOIL MOVEMENT MEASURED ON MOUNTAIN SLOPES

Control of floods and debris flows continues to be an important function of public agencies in southern California. In the San Gabriel mountains the Experiment Station continued studies to determine the quantity and rate of soil movement on steep watershed slopes. Soil moving from these slopes collects in channels and small stream courses. From there flood flows can move debris to the populated valley plain.

The rate of soil movement on steep slopes in the Los Angeles River Watershed was measured through one annual cycle of four seasons. These seasons have been classified according to the occurrence of rainfall and the moisture content of soil as dry, wetting, wet, and drying. They correspond roughly to summer-fall, fall-winter, mid-winter, and spring.

Type of installation used to measure soil movement in Los Angeles River watershed.

Rates of soil movement were determined at five sites from periodic measurements of soil moving downslope and caught in troughs installed on the contour. The study sites differ widely in physiography, representing varying gradients and aspects of slope and distance from ridges or recently downcut stream channels. Steep slopes above downcut channels are termed rejuvenated.

On the rejuvenated slopes about half the soil caught in the troughs during the year moved in during the dry season (table 4). On the non-rejuvenated slopes dry-season movement ranged from one-fifth to one-third of the annual movement. More soil moved into the troughs on rejuvenated slopes than on the others. The greatest amount of soil movement was on the south-facing rejuvenated slope. Soil caught in the trough there was equivalent to 3,200 tons per square mile per year. This was 36 times that caught in the trough on the north non-rejuvenated slope, which showed the least movement.

The kind of material moving down the slopes into the troughs differed from site to site. Trough catches at the Upper Brown site ranged from 43 to 46 percent organic matter, mostly leaves and twigs; catches at the Lower Brown site contained only 2 to 15 percent organic matter. At all sites except Lower Brown, most of the material consisted of fine soil and organic matter. At Lower Brown site some 12 percent of the material was rock at least 4.5 inches across, the largest rock weighing 156 pounds.

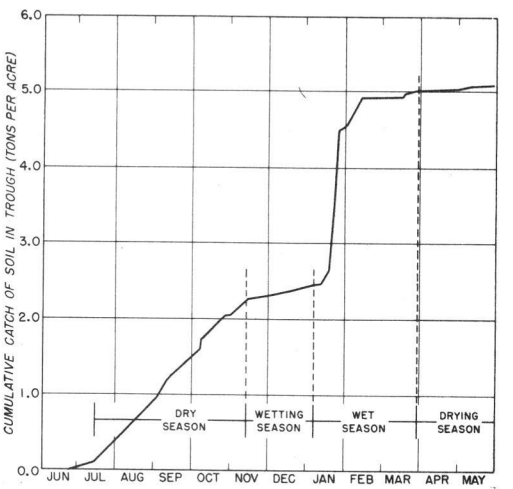
Table 4.--Soil caught below slopes at soil movement study sites

Period	Lower Brown (south rejuv.[1/][2/])	Upper Brown (south non-rejuv.)	Falls (north rejuv.)	Singing Springs No. 1 (south non-rejuv.)	Singing Springs No. 2 (north non-rejuv.)
	Tons per acre				
Dry season July 16 - Nov. 14, 1953	2.13	0.15	0.30	0.03	0.05
Wetting season Nov. 15, 1953 - Jan. 11, 1954	0.24	0.09	0.12	0.02	0.04
Wet season Jan. 12 - Mar. 31, 1954	2.57	0.11	0.13	0.07	0.03
Drying season Apr. 1 - June 1, 1954	0.07	0.09	0.03	0.03	0.02
Total	5.01	0.44	0.58	0.15	0.14
Relative rate of delivery	36	3	4	1	1

1/ Slope aspect
2/ Rejuvenated slope

Dry-season movement at all sites occurred largely as sliding and creep. Often small animals and deer started the soil moving.

Wetting-season movement which followed the first fall rains was small. Sliding of fine material almost ceased because the moisture added to the soil imparted some cohesion to the particles. At the Lower Brown site, however, the moisture lubricated the soil and loosened some rocks 5 to 15 inches in diameter which rolled into the trough. Activity of small animals and minor amounts of soil splash caused by rain accounted for the remaining movement of soil during the wetting season.



One year's catch of soil in trough below rejuvenated south slope, Lower Brown study site.

Wet-season movement at all except the Lower Brown site appeared to be caused largely by raindrop splash and rilling of bare soil. At the Lower Brown site most of the soil was moved into the trough by surface flows of water. These flows, originating on areas of impervious rock and shallow soil, picked up a load of sediment from the minor channels and from the soil, and poured the material into the trough. In the storm of January 19-20 alone, some 1,670 pounds of soil moved into the trough at the Lower Brown site.

Drying-season movement was least of all. A crust formed on the soil by the winter rains prevented most of the sliding. The spring rains were too light to cause any surface runoff or appreciable splash, and released few large rocks on the slopes. However, the crusting of the surface soil and the resulting soil stability were only temporary, and as the soil dried any disturbance tended to start the soil sliding.

Measurements on the study sites will continue at least another year before attempts are made to stabilize soil on some of the slopes. The first year's results suggest strongly that the south-facing rejuvenated slopes are the most unstable, and that there are large differences in soil movement on these slopes from season to season.

ATMOSPHERIC NITROGEN PROCESSED BY CEANOTHUS

Much of the brush cover of California's chaparral-clad mountains is Ceanothus, a genus of shrubs commonly called California lilac. It grows vigorously even on relatively infertile soils in the San Gabriel mountains of southern California. These mountain soils are markedly deficient in nitrogen. Ceanothus plants have root nodules similar to those of legumes, which are able to convert nitrogen from the air into a form usable by plants. We have found that Ceanothus, too, can improve soil fertility in this way.

Chaparral whitethorn plants were raised from seed in the laboratory. After growing 18 months in local mountain soil, the plants were harvested and the tops analyzed chemically. This analysis showed that the plants contained more nitrogen than was originally present in the soil in which they had grown. In a second test, tomato plants grown in soil containing the roots of the chaparral whitethorn grew better and contained twice as much nitrogen as tomato plants grown in similar soil which had not previously grown the chaparral whitethorn. Hoaryleaf ceanothus was also found by this test to have nitrogen-fixing ability but to a lesser degree than the chaparral whitethorn.

Other workers have also shown that plants grown close to certain Ceanothus plants make better growth than those growing with other species, but the reason for the difference had not been determined. The results of our study indicate that the stimulation factor in each case was probably nitrogen.

Because these two native Ceanothus species add nitrogen to the soil they should be considered favorably in future planting programs in the San Gabriel mountains for soil stabilization and water control. If Ceanothus is planted with other native or exotic shrubs shown to have good soil binding characteristics or to be sparing in their use of water, we would expect improved growth in the other shrubs.

DROUGHT RESISTANCE OF PLANTS HAS MANY FACETS

Field and laboratory studies this year showed that chaparral plants survive the dry southern California summer in various ways. Study of drought resistance was undertaken as part of a search for plants that could be used for stabilizing soils. One objective of the study was to seek a basis for testing the drought resistance of exotic plants which might be used for this purpose.

Native plants were studied in the field, in the lysimeter installations on the San Dimas Experimental Forest, and in controlled-climate greenhouses of the California Institute of Technology. We found that scrub oak has roots which often penetrate more than 20 feet deep, allowing the shrub to draw water from a greater depth than is possible for most other native shrubs. Scrub oak also transpires water slowly compared with other native shrubs studied, and this may be a clue to its survival under drought conditions. Coulter pine and hoaryleaf ceanothus use the available soil moisture rapidly in comparison with other species, and after available moisture has been exhausted within their root zone, apparently survive on water stored within the plant. Buckwheat sheds its leaves as soon as the available soil moisture is gone, but puts out new leaves when water is again available.

Two perennial grasses, pine blue grass and melicgrass showed different responses to drought. In a laboratory study both plants used water at the same rate, and turned brown and appeared to go dormant when soil water was no longer available. Six weeks later these plants were watered. The pine blue grass revived, but the melicgrass had already died and rotted off at the ground line. Although both grasses are native to the same parts of the southern California mountains, and although both persist through the year in the field, they reacted quite differently to drought in the laboratory.

These studies have indicated the diversity of means used by chaparral plants to survive drought. They suggest that no simple laboratory test of drought resistance will be suitable for the wide range of species that grow in southern California and similar mountain areas.

WATERSHED DAMAGES CAUSED BY LOGGING

In November the California regional office of the Forest Service issued a limited edition of a "Guide to Erosion Reduction on National Forest Timber Sale Areas." The studies which culminated in this publication were carried on jointly by members of the Experiment Station and the Regional Office, and the booklet was similarly prepared. Although the "Guide" was intended for use chiefly by forest officers and timber operators on national forest lands, numerous requests for copies received from other agencies indicate a wider need for such information. It appears likely that an edition of the booklet better adapted to general use will be required. Meanwhile, the observation of logging areas is being continued to gather material for improving a future edition of the Guide.

An examination of logged areas in the redwood--Douglas-fir region of California during 1954 revealed that watershed damages caused by logging are generally more severe there than elsewhere in the State. The regional conditions responsible for this fact include extremely steep terrain, heavy annual rainfall with storms of high intensity, large amounts of slash produced in logging, and often the continuation of logging for too long a time after the onset of heavy autumn rains.

The principal damages observed were in the form of massive earth slides into roads and streams, and the choking of creeks with tangles of slash and broken logs. By comparison, the extensive gullying seen on skidways and road slopes appeared minor, although in other parts of the State the same amount of erosion would be regarded as serious.

The mountainous part of the redwood--Douglas-fir region has a luxuriant undergrowth in the forest, and new tree growth develops rapidly in openings. Consequently, the scars of logging and erosion are quickly covered and become invisible within a few years. The vigorous regrowth, desirable as it is for watershed recovery, can not undo the damage that once occurred. Evidences of damage are found long after the event, in the form of mudbars and cut banks, in sand-filled or stagnant pools, and in tangles of old slash firmly bedded in the streams.

Most of these changes in the streams create conditions unfavorable for fish life, and result in heavy reduction of fish population. A single barrier of debris can block off a run of spawning salmon in a stream, and cause the loss of millions of young salmon. In a campaign to reduce such losses through improved logging practices, the State fisheries authorities have found the erosion reduction Guide of practical aid.

PUBLICATIONS

Anderson, Henry W.
Suspended sediment discharge as related to streamflow, topography, soil, and land use. Amer. Geophys. Union Trans. 35(2): 268-281.

Describes an analytical method for estimating the erosion potential of land areas. Presents a map of erosion potential for lands in western Oregon. Shows how erosion rates differ from potential rates under various kinds of land use.

Arnold, R. K., and C. C. Buck
Blow-up fires--silviculture or weather problems. Jour. Forestry 52(6): 408-411.

Identifies and describes some possible situations which may cause "blow-ups" on fires as a step toward their understanding and control.

Baker, Harold L., and Adon Poli
Area and ownership of forest land in San Mateo County, California. Forest Survey Release 22. 22 pp. May 1954.

Presents Forest Survey figures of land area by nonforest, noncommercial forest, and commercial forest land. Area of commercial forest land shown by timber type, age class, ownership, and size of holding.

Baker, Harold L., and Adon Poli
Area and ownership of forest land in Shasta County California. Forest Survey Release 24. 24 pp. November 1954.

Presents Forest Survey figures of land area by nonforest, noncommercial forest, and commercial forest land. Area of commercial forest land shown by timber type, age class, ownership, and size of holding.

Bentley, J. R., and L. R. Green
Stimulation of native annual clovers through applicaton of sulfur on California foothill range. Jour. Range Management 7(1): 25-30.

Plant response to application of sulfur-bearing fertilizers is described for California annual-plant range. The initial stimulation of legumes produces increased yields of grasses and legumes for a few years. Returns from plot tests of different fertilizers are described.

Callaham, R. Z.
Comments on "Is host condition the cause of insect outbreaks?" Jour. Forestry 52(6): 451-2.

Discusses an earlier article by another author.

Crafts, A. S., and C. C. Buck
Herbicidal properties of arsenic trioxide. Univ. of Calif. Agr. Expt. Sta. Bul. 739. 28 pp. February 1954.

Presents findings of greenhouse and field experiments using arsenic trioxide as a soil sterilant. Gives recommendations for use as a weed preventative.

Downing, G. L.
Ethylene dibromide sprays for controlling bark beetles in California. Misc. Paper 17. 2 pp. October 15, 1954.

Outlines procedure for using penetrating oil sprays.

Forest Survey Staff
Forest statistics for California. Forest Survey Release 25. 66 pp. December 1954.

Presents Forest Survey findings for the timber resource in California. Shows area of nonforest, noncommercial forest, and commercial forest land. Shows distribution of commercial forest land by timber type, stand-size class, and ownership. Presents timber volume by species, diameter class, and ownership. Compares growth of timber stand and volume removed by harvesting.

Gardner, R. A., and K. E. Bradshaw
Characteristics and vegetation relationships of some podzolic soils near the coast of northern California. Soil Sci. Soc. Amer. Proc. 18(3): 320-325.

Discusses characteristics and vegetation relationships of the Caspar, Noya, and Blacklock soil series. Areas studied include Bishop pine and "pygmy" forest areas in the vicinity of Fort Bragg and other places along the Mendocino coast. Lists chemical analyses of soils and predominant species of plants.

Green, L. R., and J. R. Bentley
Some costs and returns from applying sulfur fertilizers on rangeland. California Cattleman, pp. 8-9 May 1954. Also in Westland Pasture Journal 5(2): 2 pp.

Methods of sulfur fertilization at the San Joaquin Experimental Range are described. Sixty pounds of sulfur per acre, applied at 3-year intervals, is an economical treatment. Costs and returns are compared for three common carriers of sulfur: soil sulfur, gypsum, and single superphosphate.

Hallin, William E.
Unit area control -- its development and application. Misc. Paper 16, 10 pp. 1954.

Unit Area Control focuses attention upon the groupwise structure of forests and the necessity for providing for regeneration at appropriate times and places in order to create proper distribution of age-classes. When ready for final harvest, homogeneous groups in the stand are clearcut.

Hamilton, Everett L.
Rainfall sampling on rugged terrain. U. S. Dept. Agr. Tech. Bul. 1096. 41 pp. December 1954.

Describes studies made to investigate the subject of rainfall sampling. Supplies information concerning the behavior of rainstorms in southern California mountains. Describes an improved method of measuring rain in mountain lands. Presents a method for correcting inaccurate measurements.

Iloff, P. M. Jr., and N. T. Mirov
Composition of gum turpentines of pines, XIX. A report on Pinus ponderosa from Arizona, Colorado, South Dakota and Northern Idaho. Jour. Amer. Pharm. Assoc. Sci. Ed. 43(6): 373-378.

Gives methods and results of analysis of turpentines of ponderosa pine from different parts of its range. Results provide a basis for distinguishing three forms of ponderosa pine: a Pacific Coast form, an Intermountain form, and an east-of-the-Rockies form.

Iloff, P. M. Jr., and N. T. Mirov
Composition of gum turpentines of pines. XXI. A report on Pinus quadrifolia from southern California, P. lumholtzii from Durango, Mexico, and P. caribaea from Nicaragua. Jour. Amer. Pharm. Assoc. Sci. Ed. 43(12): 738-41.

Gives methods and results of turpentine analyses which showed that Caribbean pines from Nicaragua differs considerably from slash pine of southeastern United States.

Iloff, P. M. Jr., and N. T. Mirov
Composition of gum turpentines of pines. XXII. A report on Pinus rudis and P. hartwegii from Mexico and P. insularis from Philippines. Jour. Amer. Pharm. Assoc. Sci. Ed. 43(12): 742-5.

Gives methods and results of turpentine analyses which suggested that rudis pine and Hartweg's pine should not be considered merely varieties of Montezuma pine but rather as independent species.

Kimmey, James W.
How to determine when an area was logged. Jour. Forestry 52(1): 40.

Dates on "snoose" cans, pore layers on conks, logging wounds, and annual rings on remaining trees aid in dating year of logging.

Kimmey, James W.
Cull and breakage factors for pines and incense-cedar in the Sierra Nevada. Res. Note 90. 4 pp. April 13, 1954.

Provides flat cull and breakage factors in percent of board-foot, merchantable tree volume by Dunning tree classes for ponderosa, Jeffrey, and sugar pines and for incense-cedar in the Sierra Nevada.

Kimmey, James W.
Determining the age of blister rust infection on sugar pine. Res. Note 91. 4 pp. April 16, 1954.

Demonstrates from California and Oregon data that infection of sugar pine by white pine blister rust through needles of the current season is about twice as great in the Sierra Nevada as in Oregon.

Kraebel, Charles J. (Collaborator)
A guide to erosion reduction on national forest timber sale areas. 78 pp. U. S. Forest Service, California Region, San Francisco.

Outlines factors influencing watershed conditions in logging areas. Discusses watershed damage caused by logging practices. Describes road building and logging practices designed to preserve the stability of soil and stream channels.

Lightle, Paul C.
The pathology of Elytroderma deformans on ponderosa pine. Phytopathology 44(10): 557-569.

Outlines the normal life cycle and reports investigations on the biology of the most important needle disease fungus on pines in the West. In addition to killing needles, the fungus deforms twigs and sometimes induces witches brooms. Part of these effects are apparently from a toxin.

May, Richard H.
Output of forest products in California, 1952. Forest Survey Release 23. 10 pp. July 1954.

Summarizes output of forest products in California by principal products, species, and region of production.

Mirov, N. T.
Lodgepole pine discovered and misnamed. Madrono 12: 156-157.

Discusses discovery and nomenclature of lodgepole pine.

Mirov, N. T.
Studies of the chemical composition of turpentine of the genus Pinus in relation to taxonomy. 8th International Botanical Congress. pp. 47-49. Paris.

Reports work done at Institute of Forest Genetics on application of chemical findings to problems of botany and tree breeding.

Mirov, N. T.
Apache pine and its relation to ponderosa pine. Madrono 12: 251-252

Judging from chemical composition of turpentines, Apache pine should be considered an independent species from ponderosa pine. Significance of this conclusion for tree breeding is indicated.

Mirov, N. T.
Chemical composition of gum turpentines of pines of the United States and Canada. Jour. Forest Products Res. Soc. 7(1): 1-7.

A review paper for reference use of industrial and research workers. Based largely on Station biochemical work to inventory turpentines of the pines of the world.

Mirov, N. T.
Composition of turpentines of Mexican pines. Unasylva 8(4): 167-173.

A reference paper, for use of research foresters, based almost exclusively on turpentine inventory studies by Station staff.

Mirov, N. T., P. M. Iloff, Jr., and L. B. Gordon
Composition of gum turpentine of pines, XVIII. A report on Pinus pungens, P. glabra, and P. teocote. Jour. Amer. Pharm. Assoc. Sci. Ed. 43(1): 13-15.

Gives methods and results of oleoresin analysis as part of turpentine inventory studies.

Mirov, N. T., and P. M. Iloff, Jr.
Composition of gum turpentines of pines, XX. A report on Pinus chihuahuana from Durango, P. apacheca from Arizona, and P. monticola from Northern Idaho. Jour. Amer. Pharm. Assoc. Sci. Ed. 43(6): 378-381.

Gives methods and results of oleoresin analysis as part of turpentine inventory studies.

Poli, Adon, and Harold L. Baker
Ownership and use of forest land in the Redwood--Douglas-fir subregion of California. Tech. Paper 7. 76 pp.

Presents results of a cooperative study made by the Agricultural Research Service and Forest Service. Discusses ownership in relation to use of forest land, types of owners, size of holdings, operating tenure, how acquired, how used, and effect of ownership on management.

Righter, F. I.
Forest tree improvement research in California. Jour. Forestry 52(9): 680-682.

Describes the aims and current program of forest genetics studies in pines.

Rowe, P. B., C. M. Countryman, and H. C. Storey.
Hydrologic analysis used to determine effects of fire on peak discharge and erosion rates in southern California watersheds. 49 pp. Calif. Forest and Range Expt. Sta., Berkeley.

Describes procedures of hydrologic analysis used in appraising the effects of watershed burning upon flood damage.

Schubert, G. H.
Viability of various coniferous seeds after cold storage. Jour. Forestry 52(6): 446-7.

Seed of many conifers can be collected in large quantities during good seed years with assurance that they will retain high viability for intervals sufficiently long to tide over the poor seed years - providing the seed is properly handled and stored.

Smith, H. H.
Seasoning California hardwoods. Tech. Paper 5. 8 pp. February 1954.

Presents results of experimental air drying and subsequent kiln drying of California laurel, madrone, tanoak, and golden chinkapin. It was found that California laurel can be dried satisfactorily. One-inch madrone and tanoak can be dried if handled carefully, but thicker lumber of these woods is difficult to dry even under carefully controlled conditions. More study will be needed to develop drying techniques for chinkapin, which was most difficult to handle.

Sinclair, J. D.
Erosion in the San Gabriel Mountains of California. Amer. Geophys. Union Trans. 35(2): 264-268.

Describes topography, geology, soil, and climate of the San Gabriel Mountains in southern California. Tells how land erosion may be accelerated by disturbances of vegetation and soil. Outlines programs for prevention and correction of erosion and research projects.

Staff, San Dimas Experimental Forest
Fire-flood sequences on the San Dimas Experimental Forest. Tech. Paper 6. 22 pp.

Describes how a brush fire burned into experimental watersheds of the San Dimas Experimental Forest. Gives eyewitness account and analytical discussion of flood flows resulting from heavy rains on the fire-damaged watershed. Presents photo story of the 1954 fire-flood sequence.

Struble, G. R., and R. C. Hall
Telephone cables invaded by shrub bark beetle in Pacific coastal region. Jour. Econ. Entomology 47(5): 933-4.

Describes an unusual type of damage to polyethylene cable by an insect that normally breeds in cascara.

Talbot, M. W.
Some recent developments in California range management. Jour. Forestry 52(8): 597-598.

Research projects of the Range Management Research Division are discussed to show how range management ties in with other wildland uses. The need for closer coordination in the harvesting of the three main wild land crops -- water, timber, and forage -- is stressed.

Wagener, Willis W.
Longevity under adversity in conifers. Science 119: 883-884.

Commentary on an earlier article on the subject by Edmund Schulman. Points out conditions favoring longevity.

Wagener, Willis W., and Ross W. Davidson.
Heart rots in living trees. The Botanical Review 20(2): 61-134.

A comprehensive survey of the principal world literature on heart rots, embracing 345 titles.

Wieslander, A. E., and Clark H. Gleason
Major brushland areas of the Coast Ranges and Sierra-Cascade foothills in California. Misc. Paper 14. 9 pp.

Defines woodland, chaparral, and associated cover types which pose problems in land use below California's commercial timber zone. Gives the areas of each type. (Blue-line prints of brushland map, scale 1 inch to 16 miles, can be obtained from the U. S. Forest Service, 630 Sansome Street, San Francisco 11, at $1.00 each.)